INVESTIGATING ENERGY USAGE AMONG LOW INCOME HOUSEHOLDS AND IMPLICATIONS FOR FIRE RISK

By

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Research thesis presented in partial fulfilment of the requirements for the degree of Master of Philosophy in Disaster Risk Science and Development in the Faculty of Arts of Social Sciences at Stellenbosch University

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March 2018

DECLARATION

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ABSTRACT

Fires have been a constant problem amongst residents of low-income residential areas such as Lwandle, Nomzamo and Asanda Village in the City of Cape Town. A common cause of these dwelling fires have been attributed to the usage of unsafe and potentially hazardous forms of energy used for daily activities such as candles, for lighting, paraffin for cooking and boiling water and firewood for heating of dwellings. It has often been prescribed that key to curbing dwelling fires among low-income residential areas is to increase people's access to more modern and safe forms of energy such as electricity. Yet despite near universal access to electricity in these areas, dwelling fires remain a frequent occurrence because many households continue to utilise non-electric energy sources, as well as increasing reports of fires caused by faulty or informal electric connections.

This thesis has set out to examine the energy sources being utilised by low-income households in Lwandle, Nomzamo and Asanda Village, to understand the factors which influence these energy use choices, what implications these energy choices have for fire risk, as well as what measures households employ to mitigate the risk of fire. This research utilised a mixture of qualitative and quantitative data collection methods including focus group sessions with residents and a household survey to collect information on household energy use strategies, perceptions of safety and accessibility of energy sources and experiences of energy related fires from residents residing in different types of dwellings.

Based on the findings, the thesis observed that while electricity is the predominant energy source used in the study site, households may be unable to fully utilise it because of financial constraints or issues regarding physically accessibility to and quality of electrical connections. Approximately 67.2% of households were observed employing an energy stacking approach, alternating between electric and non-electric energy sources, namely paraffin, to meet their daily energy needs. A potential consequence of this energy stacking approach employed by households to meet their energy needs is that the majority of households continue to face the risk of a dwelling fire caused by non-electric energy sources. While non-electric energy sources were both perceived and experienced by residents as the main cause of dwelling fires in the study site, electricity was found to contribute to a number of dwelling fires, with a slight increase in the number of fires caused by electric sources observed over the last few years. Despite households being frequently exposed to many potentially hazardous electric and non-electric energy sources, many households implement a number of measures to reduce their exposure and mitigate the risk of experiencing a dwelling fire.

KEYWORDS

Energy, Electricity, Dwelling Fire, Risk, Low-Income Residential Area, Energy Stacking,

OPSOMMING

Brande was ‘n voortdurende probleem onder lae-inkomste residensiële inwoners van areas soos Lwandle, Nomzamo en Asanda Dorp in die Stad Kaapstad. ‘n Algemene oorsaak van hierdie brande is toegeskryf aan huishoudings se gebruik van onveilige and potensieel gevaarlike vorme van energie vir daaglikse aktiwiteite soos kerse, beligting, paraffien vir kook en kookwater en vuurmaakhout vir hitte. Die toename in mense se toegang tot meer modern en veiliger vorme van energie soos elektrisiteit is al dikwels voorgeskryf as die sleutel tot die bekamping van woningbrande in lae-inkomste residensiële areas. Tog ten spyte van naby universele toegang tot elektrisiteit in hierdie areas, as gevolg van talle huishoudings wat steeds nie-elektriese energiebronne gebruik, ‘n toename in brande veroorsaak deur foutiewe of informele elektriese konneksies aangemeld, bly woningbrande ‘n gereelde gebeurtenis.

Hierdie tesis het uiteengesit om die energiebronne wat deur lae-inkomste huishoudings in Lwandle, Nomzamo en Asanda Dorp gebruik word, die faktore wat hierdie energieverruikskeuses beïnvloed, die implikasies van hierdie energiekeuses op brandrisiko, asook die maatreëls geneem deur huishoudings om brandrisiko te verminder, te ondersoek. Hierdie navorsing het ‘n kombinasie van kwalitatiewe en kwantitatiewe data-insamelingsmetodes gebruik, insluitend fokusgroep sessies met inwoners en ‘n huishoudingsvraelys om inligting oor huishoudelike energieverbruikstrategieë, persepsies van veiligheid en toeganklikheid van energiebronne, asook energie verwante brandervaringe van inwoners in verskillende tipes wonings, in te samel.

Op grond van die bevindinge het hierdie proefskrif waargeneem dat alhoewel elektrisiteit die oorheersende energiebron in die studie-area is, is huishoudings, as gevolg van finansiële beperkings of kwessies rakende fisiese toeganklikheid en kwaliteit van elektriese verbindings, moontlik nie in staat om dit ten volle te benut nie. Ongeveer 67.2% van huishoudings is waargeneem wat ‘n energiestapelingsbenadering volg, waar daar tussen elektriese en nie-elektriese energiebronne soos paraffien, gewissel word, om aan hul daaglikse energiebehoeftes te voorsien. ‘n Potensiële gevolg van hierdie energiestapelingsbenadering gevolg deur huishoudings om aan hul energiebehoeftes te voorsien is dat die meerderheid huishoudings steeds die risiko van woningbrande veroorsaak deur nie-elektriese energiebronne, in die gesig staar. Terwyl inwoners waargeneem en ervaar het dat nie-elektriese energiebronne die hoof oorsaak van woningbrande in die studie-area is, is daar gevind dat elektrisiteit, met ‘n effense toename in die aantal waargenome brande oor die afgelope paar jaar veroorsaak deur elektriese bronne, tot ‘n aantal woningbrande bydra. Ten spyte van huishoudings wat dikwels aan verskeie potensieël gevaarlike elektriese en nie-elektriese energiebronne blootgestel word, implementer baie huishoudings ‘n aantal maatreëls om hul blootstelling aan en risiko van ‘n woningbrand te verminder.

SLUITELWOORDE

Energie, Elektrisiteit, Woningbrand, Risiko, Lae-inkomste Residensiële Area, Energiestapelling

ACKNOWLEDGEMENTS

Several people have provided assistance in the completion of this thesis.

Firstly, I would like to thank my supervisor Dr Robyn Pharoah for her guidance, insight and support throughout this research process.

Secondly, I would like to thank Masa Soko, the manager of the Lwandle Migrant Labour Museum for her invaluable assistance with understanding the study site, helping to select research assistants for interviews, focus groups and surveying residents.

Thirdly, I am very grateful to the Councillors of Lwandle and Nomzamo, Mr Jungidono and Mr Maxheke respectively for taking their time to assist me with organising focus groups between myself and community members.

Next, I owe major thanks to the research assistants; Precious November, Ayanda Soko, Amanda Soko, Yolisa Ntshayi, Bulelani Mayila, Chuman Mbewana, Kuhle Dlangalavu, Nolubalala Dlangalavu, Mabhuti Gcwabe and Sanga Mzwakali, who assisted me in my data collection, particularly for the distribution of the household survey.

I must also say a great thank you to my boss/mentor Dr Ailsa Holloway for allowing me to continue working while giving me time to work on this thesis.

Finally, I must thank the residents of Lwandle, Nomzamo and Asanda Village for literally welcoming the researchers and myself into their homes and giving us their time to participate in this research.

ABREVIATIONS

BYD	-	Backyard Dwellings
CoCT	-	City of Cape Town
DiMP	-	Disaster Mitigation for Sustainable Livelihoods Programme
DoE	-	Department of Energy
IEA	-	International Energy Agency
INEP	-	Integrated National Electricity Programme
ISD	-	Informal Settlement Dwellings
JPOI	-	Johannesburg Plan of Implementation
LPG	-	Liquid Petroleum Gas
RADAR	-	Research Alliance for Disaster and Risk Reduction
RSA	-	Republic of South Africa
SEA	-	Sustainable Energy Africa
SoE	-	State of Energy

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1 INTRODUCTION

1.1 THE SITUATION: REDUCING RESIDENTIAL FIRES THROUGH INCREASED ELECTRIFICATION

Fires have been a constant problem amongst residents of low-income residential areas in the City of Cape Town (CoCT) (IFRC 2010; Pharoah, Fortune, Chasi & Holloway 2013). Residential fires are recognised as a major hazard – phenomena which may have a significant impact on residents' livelihood, damaging or destroying their homes, causing people to lose much of their personal belongings, displacing them, disrupting their ability to work as well as causing injury and even death to household members (Solomon 2006). Low-income households are considered to be highly vulnerable to residential fires due to factors such as limited financial resources, an 'at risk' dwelling type, settlement location and density, their lack of resources, capacities or access to services, and marginalised political and economic position within urban areas which make them more susceptible to being negatively impacted by such hazards. An often under-acknowledged source of risk, which threatens low-income households, is the usage of unsafe and dangerous forms of energy. A common cause of these dwelling fires is accidents related to the use of unsafe and dangerous forms of energy which include candles for light, and paraffin/gas stoves or open wood fires for cooking and heat generation being either knocked over or being left unattended which sets fire to its surrounds (Pharoah, Fortune, Chasi & Holloway 2013; Wolpe & Reddy 2010). In Cape Town, over 16 000 fires have been reported in residential areas between 2009 and 2016, with the source of ignition for most of these dwelling fires being attributed to non-electric energy sources (Western Cape Government 2017).

A commonly prescribed solution to curbing non-electric energy-related hazards and reducing their risk of causing dwelling fires is to increase people's access to more modern and safe forms of energy such as electricity (Albertyn, Rode, Millar, & Peck 2012; Spalding-Fecher 2005). Electricity has been perceived as a safer and cleaner energy source, because it does not rely on combustion, i.e. producing flames to create energy to provide heat or light. The assumption that electricity is safer aligns to paradigms and development policies such as the Johannesburg Plan of Implementation (JPOI) and Sustainable Development Goals (Goal No. 7) which argue that access to modern energy is key to building sustainable settlements, curbing impoverishment and creating safer households (Vermaak 2014; ICSU & ISSC 2015). Since the early 1990s, South Africa has embarked on a campaign to create universal access to formal electrification for all South Africans. The goal of this campaign has been to provide access to electrical infrastructure and services, especially to poor South Africans and low-income households to address inequalities, allow opportunities for household development and to assist in eradicating poverty (Keller 2012).

1.2 PROBLEM STATEMENT: MIXED ENERGY STRATEGIES INCREASE FIRE RISK

It was estimated in 2015 that approximately 94% of households across Cape Town had access to electricity (CoCT 2015). Yet despite near universal access to electricity, it is uncertain whether increased access to electricity has actually assisted in reducing the risk of residential fires among low-income households (CoCT 2015). Between 2005 and 2015, statistics on fire incidences within Cape Town indicate an increase in the number of dwelling fires taking place in residential areas (Pharoah, Fortune, Chasi & Holloway 2013; Western Cape Government 2017).

There appears to be a prevailing assumption that once households gain access to electricity, they would shift away from using non-electric energy sources and embrace electricity as their main source of energy. However, there is evidence that many low-income households in Cape Town continue to utilise non-electrical energy sources such as paraffin and candles on a frequent basis. This is often because of issues concerning affordability and quality of access of energy sources such as electricity (Swart & Bredenkamp 2012; Mohlakoana & Annecke 2008). Although electricity is generally considered a safe and clean energy source (i.e. it does not produce emissions) for households, it is also a potential cause of fires. According to the City of Cape Town database of fire incidents between 2009 and 2016, there has been a 132% increase of cases of residential fires caused by faulty electrical wiring and appliances among formal housing, and 334.5% among informal dwellings (Western Cape Government 2017).

Consequently, it appears that low-income households are potentially faced by a variety of different energy-related hazards, which could have major impacts on the livelihoods of residents. While there is a general awareness of the variety of energy sources that low-income households have access to, i.e. electricity, paraffin, firewood, candles, gas, etc., there is relatively little information about actual energy usage strategies employed by such households and the implications that these energy sources have for the incidence of dwelling fires. Therefore, this thesis sets out to explore the energy use patterns employed by low-income households residing in the suburbs of Lwandle, Nomzamo and Asanda Village, located in Somerset West in the Cape Town Metropolitan area, order to better understand the energy-related fire risk environment of such households and determine whether electrification reduces fire risk.

1.3 RESEARCH PURPOSE: UNDERSTANDING HOUSEHOLD ENERGY USAGE

The purpose of this research shall be to examine what energy sources are being utilised by low-income households, and their implications for fire risk in these households. The specific research objectives of this thesis are as follows:

I. To observe and document what energy sources are utilised by households of the study site to meet their needs;
II. To investigate factors which influence households' choice of energy sources;
III. To examine how energy choice may contribute towards household fire risk; and
IV. To examine strategies employed by households to reduce the risk of fire caused by energy sources.

1.4 OVERVIEW OF THESIS STRUCTURE

This thesis has been structured along the following lines. Section two of this thesis will comprise of the review of literature, pertaining to low-income household energy usage, both in South Africa and internationally; electrification and access to energy by households in South Africa; and the relationship between energy choices and dwelling fires. The third section provides an overview of the methodology and methods used to gather, consolidate and critically analyse the primary and secondary data collected – this includes describing the scoping process, selection of the study site, and approach to data collection and analysis. The fourth section shall give a brief background to the history and contemporary characteristics of households, electrification patterns, and dwelling fires. The fifth section will reveal the findings from the engagement with residents, looking at household perceptions of energy sources and dwelling fire risk; what energy sources are most commonly utilised by households and for what activities; what factors promote or constrain the usage of particular energy sources; and, finally, experiences of dwelling fires and efforts to reduce their fire risk. The sixth section provides an overview and critical analysis of findings from the research, relating findings back to the literature, and implications of the research. The final chapter draws out the key conclusions of the research and makes recommendations for future research.

2 REVIEW OF ENERGY AND RISK LITERATURE

2.1 INTRODUCTION

There has been much research conducted on energy use strategies employed by households and the factors, which influence these usage choices, both internationally, as well as among households in South Africa. Similarly, there are a number of different kinds of research done on residential fires in South Africa, often among informal settlements and dwellings, which identify energy sources such as paraffin and candles as leading causes to such incidences. However, there is relatively little literature either internationally or locally that combines the two, examining household energy choices and the implications these choices have upon household fires. This section of the thesis will examine literature at both international and local level pertaining to theories regarding low-income household energy usage, electrification and access to energy by households in South Africa, and the relationship between energy sources and dwelling fires.

2.2 ENERGY USAGE AMONG LOW INCOME HOUSEHOLDS

2.2.1 Categorisation of energy sources and usage

The ability to access and harness energy has and continues to be essential to human livelihood, welfare and development (Rehfuess & WHO 2006; HESASA 2013a). Energy is central to practically all aspects of daily human life through activities such as cooking food, powering appliances for communication and learning, provision of warmth, and light to read and study at night, to name a few (IEA 2014**;** Wolpe & Reddy 2010). Traditionally, humans relied on the ignition of biomass fuels to generate fire, harnessing the thermal radiation emitted and utilising it to meet their needs such as cooking, warmth and light (www.scienceclarified.com**;** Bithas & Kalimeris 2016). Such 'traditional' energies include igniting sources/fuels such candles, wood fuels, coal and animal waste (Mehlwana & Qase 1999). Since the 19th century, new forms of energy have become available for households to utilise to meet their energy needs, such as paraffin (kerosene), natural gas (also known as LPG), and electricity. LPG is used relatively scarcely among South African households, which according to Lloyd (2014a: 4), is surprising as "other societies at a stage of development similar to South Africa have found it the urban fuel of choice". Energy sources have traditionally been categorised along a hierarchy according to their costs, ease of use, efficiency, cleanliness and safety (Uhunamure, Nethengwe & Musyoki 2009; Barnes, Mathee, Thomas & Bruce 2009). The use of different energy sources has often been understood and analysed through the energy ladder model as depicted below in Figure 1 (van der Kroon, Brouwer & van Beukering 2011; Schlag and Zuzarte 2008).

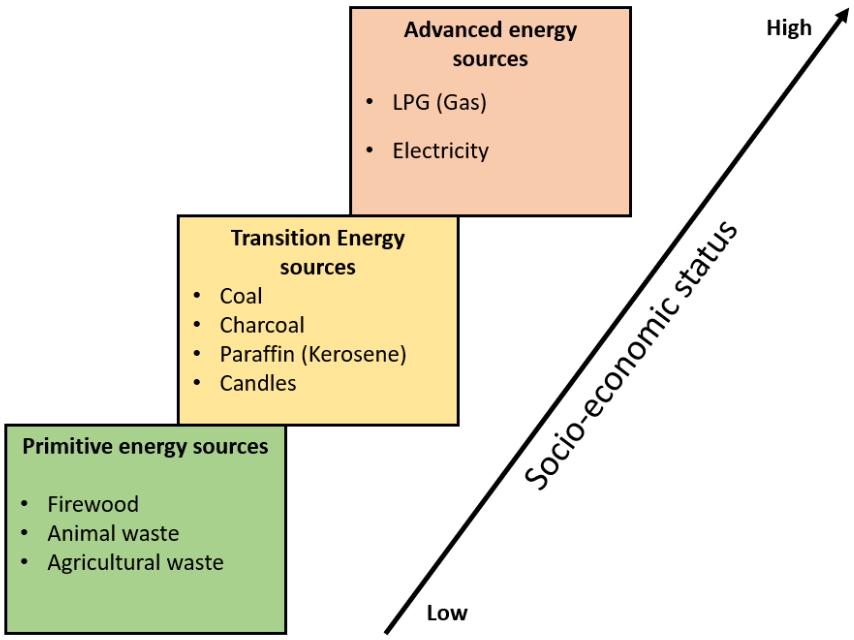


Figure 1 Depiction of Energy Ladder Model

Schlag and Zuzarte (2008) have categorised these fuels into three sets or steps: 'Primitive' energy sources including firewood, animal waste and agricultural waste; 'Transition' energy sources including Charcoal, coal, paraffin and candles; and 'Advanced' fuels including LPG (gas) and electricity. According to this model, while primitive energy sources are cheaper to acquire, they are considered inferior fuels because they are considered less efficient, emit pollutants and are generally unsafe. The further up the ladder one goes, the fuels become more expensive, but more efficient, cleaner, safer and (and in the case of electricity) highly versatile in their powering of various appliances and technologies (Mvondo 2010). It has been theorised that the type of energy a household utilises is largely dependent on their socio-economic status (Hosier & Dowd, 1987). For example, higher income households will employ advanced energy sources such as gas or electricity to meet their energy needs, while lower income households will utilise energy sources in the transition set, such as paraffin for cooking, boiling water and or warmth and candles for lighting (van der Kroon, et al. 2011).

A central theme to the energy ladder model is that when a household's income increases they will shift their energy usage from one set of fuels to the higher set (Uhunamure, et al. 2009; van der Kroon, et al. 2011); increased incomes means that households will abandon the less efficient energy sources they had relied on before and replace them with the cleaner, more efficient and safer energy sources with more sophisticated appliances and technologies of the advanced set to meet all their energy needs (Albertyn, et al. 2012). Therefore, once a household progresses to the modern energy phase, there should be no need to resort to 'lower' energy sources such as firewood, coal, candles and or paraffin.

2.2.2 Increasing access to electricity among South African Households

Towards the end of the 20th century, recognising the importance of energy systems to human wellbeing, sustainable development and the eradication of poverty, the Johannesburg Plan of Implementation (JPOI) developed and initiated at the 2002 World Summit on Sustainable Development called for improving access to reliable and affordable energy services as a global priority (UN 2002). The call for "access to affordable, reliable, sustainable, and modern energy for all" (ICSU & ISSC 2015) by 2030 has recently become the 7th goal of the Sustainable Development Goals (SDGs) launched in 2015. While many developing states, especially in sub-Saharan Africa, are struggling to provide access to modern energy services to their citizens, South Africa has made enormous strides in making modern energy universal to its people.

Since the 1990s, the South African government has endeavoured to increase access to modern energy services to its citizens, particularly those who are poor and were previously disadvantaged by the policies of the apartheid government. In 1994, it was estimated that only 36% of households across the country had access to electricity, the remaining 66% were mostly low-income and impoverished households forced to rely on non-electrical energy sources to meet their daily energy needs (Wolpe & Reddy 2010). As depicted in Table 1, the report in 1996 by the Energy and Development Research Centre showed that in low-income residential areas such as Langa and Khayelitsha in the City of Cape Town, only 47% of households had access to electricity, with informal settlement dwellings (ISDs) and backyard dwellings (BYDs) (see '*Definitions of different Dwelling Types*' below), which made up the majority of dwellings, having 36% and 21 % access respectively (Simmonds & Mammon 1996).

Table 1 Access to electricity in low-income households in Langa and Khayelitsha in Cape Town (1995) (Simmonds & Mammon 1996)

Dwelling Type	No. of dwellings	No. of electrified (%)
Formal Dwelling	7 057	6 634 (94%)
Informal Settlement Dwelling (ISD)	28 133	11 834 (36%)
Backyard Dwelling (BYD)	7 381	1 550 (21%)
Total	42 571	20 018 (47%)

Definitions of different Dwelling Types	
Formal Dwelling	- A dwelling which has been built in compliance with current planning and building regulations (RSA 2010); - Land the dwelling is built on privately owned land; - Such dwellings typically have access to services such as electricity, water and ablutions (HDA 2013).
Informal Settlement Dwelling (ISD)	- A makeshift dwelling, commonly called a "shack", that does not comply with current planning and building regulations (RSA 2010); - Commonly built using materials such as wood, corrugated iron, and or plastic (HDA 2013) - Such dwellings are often constructed on land that the occupants have no legal claim to, or occupy illegally (Tshangana 2013); - Such dwellings have little to no access to services, such as electrification, water and ablutions, delivered to their dwelling and have to rely on informally constructed, illegal or communal facilities and services.
Backyard Dwelling (BYD)	- A makeshift dwelling, akin to an ISD/Shack, which does not comply with current planning and building regulations. These are usually built with materials such as wood, corrugated iron, and or plastic (Tshangana 2013); - Such dwellings are located within the properties of formal dwellings, and are usually occupied by relatives of the property owner, or are rented by tenants ; - Such dwellings have little to no access to services such as electricity, piped water and ablution facilities and use amenities provided to the primary, formal dwelling (HDA 2013).

Electrification rates reflected growing levels of informality, particularly in urban areas. In the early 1990s the repealing of apartheid laws, which restricted movement of non-whites in South Africa, was associated with rapid in-migration to major urban centres and metropolitan municipalities. The majority of these migrants were previously disadvantaged and impoverished Black South Africans from the former homelands, seeking better opportunities for themselves and families (Huchzermeyer 2006; Durand-Lasserce & Royston 2002). Cape Town, like most major cities in South Africa during this period, was poorly prepared to accommodate this influx of migrants (Knight 2004). As a consequence of the shortage of housing for low-income groups and their lack of access to the formal housing market, many people began to erect informally constructed 'shack' dwellings on available land or in the backyard of properties in formal low-income residential areas such as Nyanga and Langa (Durand-Lasserce & Royston 2002; Mehlwana 1997). As more migrants arrived in the city/cities, the number of shacks increased, creating clusters of increasingly large and dense informal settlements. With the increased influx of people and the establishment of new households in the city came increased demand for services to be provided to these dwellings and settlements. In particular, increased demands for modern energy services such as electricity, which had been promised by the new democratically elected government, grew (Knight 2004; Bekker, Eberhard, Gaunt, & Marquard 2008; Spalding-Fecher 2005).

Access to electrical services and infrastructure was limited amongst many of the newly established low-income informal households. Limited access electrical services to ISDs and BYDs during the 1990s was attributed to the reluctance of city officials to service these dwellings which were not in accordance to building codes or urban planning, that had uncertain tenureship because many such households occupied land illegally, as well as the negative perceptions held towards informality (Pharoah, Fortune, Chasi & Holloway 2014; Gaunt, Salida, Macfarlane, Maboda, Reddy & Borchers 2012; Wekesa, Steyn & Otieno 2011). Therefore, city authorities were reluctant to provide services in order to avoid encouraging the growth of informal areas. As a result, many of these un-electrified households (almost all of which were informal dwellings) were forced to rely on non-electric energy sources such as paraffin, candles, coal and biofuels to meet their daily energy needs (this will be discussed in next section) (Simmonds & Mammon 1996).

However, in response to rising poverty, informality, shortages of housing for low-income groups and the increasing demand for electricity in the city, during the latter half of the 1990s the government initiated policies and implement strategies to improve access to electricity (Tredoux 2009; Huchzermeyer 2006). In 1998, the *White Paper on the Energy Policy of the Republic of South Africa* was written, which recognised the need for distributing modern energy services throughout the country to undermine poverty and enhance the development of households and society as a whole (Department of Minerals and Energy 1998). Shortly afterwards, the government launched an 'accelerated national electrification programme' named the "Integrated National Electricity Programme" (INEP) which was specifically focused to provide access to modern energy services to low-income households throughout the country (SEA 2014; Prasad & Visage 2006). The primary objective of the INEP was to achieve universal access of modern energy services to all South Africans by 2025, and thereby help to reduce poverty and enhance livelihoods across cities. Originally, the INEP was focused on distributing electrical services to subsidised formal housing built by the government in its battle to overcome the housing crisis and informality (SEA 2014).

By 2013, it was estimated in the South African General Household Survey that the South African government had provided over 5.7 million households with physical access to electricity across the country, increasing the proportion of the population with access to modern energy services from 36% to 88% since the end of apartheid (RSA 2014). According to the City of Cape Town State of Energy (CoCT SoE) 2015 Report, it was estimated that over 94% of all households across dwelling types have access to electricity through either formal or informal connections – one of the highest rates of electrical access in the country. The report argues that with increased access to electricity, there was a significant decline in the number of low-income households reliant on paraffin, candles, firewood, coal, etc. This can be observed in Figure 2 below, which shows a major decline in paraffin usage for cooking among low-income households between 2001 and 2011, against increasing usage of electricity. The report also showed increased usage of gas among low-income households for activities such as cooking, as shown in Figure 2, although it is still only employed by a small percentage of households.

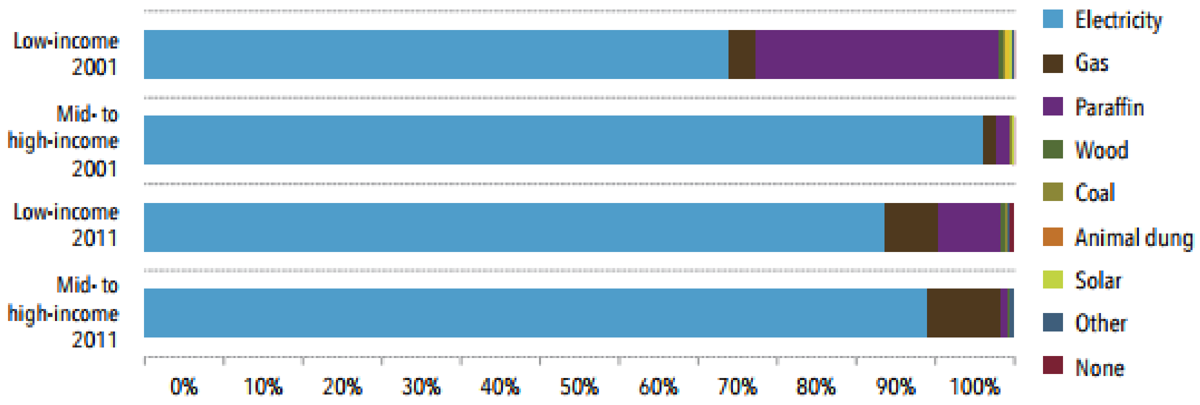


Figure 2 Fuels used for cooking by income group in Cape Town in 2001 and 2011 according to the CoCT SoE 2015 Report

In the last 15 years, the many ISDs and BYDs have also acquired access to electricity, often through informal connections and wiring between their dwelling and neighbouring electrified dwellings (Franks & Prasad 2014; Kovacic, Smit, Musango, Brent, and Giampietro 2016). Increased access to electricity has been perceived to be hugely beneficial to low-income households, providing power for a number of appliances that can improve the standard of living for a household, i.e. refrigeration to store fresh food, provide light to read and study, powering communication devices and other luxury appliances and media devices such as sound systems and televisions (Lloyd, Cowan & Mohlakoana 2004).

2.2.3 Mixed energy usage among low-income households

Despite the impressive progress made in the last two decades for universal access to electricity, low-income households in South Africa often continue to use a range of energy sources. While electricity is the predominant source of energy for activities such as for lighting cooking and heating, often households will utilise a variety of energy sources to provide power for each of these activities or even multiple energy sources (RSA 2012b; Winkler, Simões, La Rovere, Alam, Rahman & Mwakasonda, 2011; Panday & Mafu 2007; Swart & Bredenkamp 2012).

According to van der Kroon et al. (2011), despite increased access to energy sources such as electricity, there is no guarantee that it would necessarily mean that households will transition away from primitive and inferior energy sources immediately or completely (van der Kroon et al. 2011). It has been observed that many low-income households internationally continue to employ transition energy sources for some activities, and modern sources for others, for example, electricity for lighting but paraffin for cooking (SEA 2014; Winkler et al. 2011; Swart & Bredenkamp 2012; Mohlakoana & Annecke 2008), or switch between different sets of energy sources for a particular activity, such as switching between paraffin and electricity for cooking and candles and electricity for lighting. This employment of a mixture of energy sources by such households, known as the 'energy stacking' approach as depicted in Figure 3 below, contrasts with the 'energy ladder' model, which posits that once households have the resources to access advanced energy sources like electricity, they stop using more primitive sources (Uhunamure, et al. 2009; van der Kroon et al. 2011).

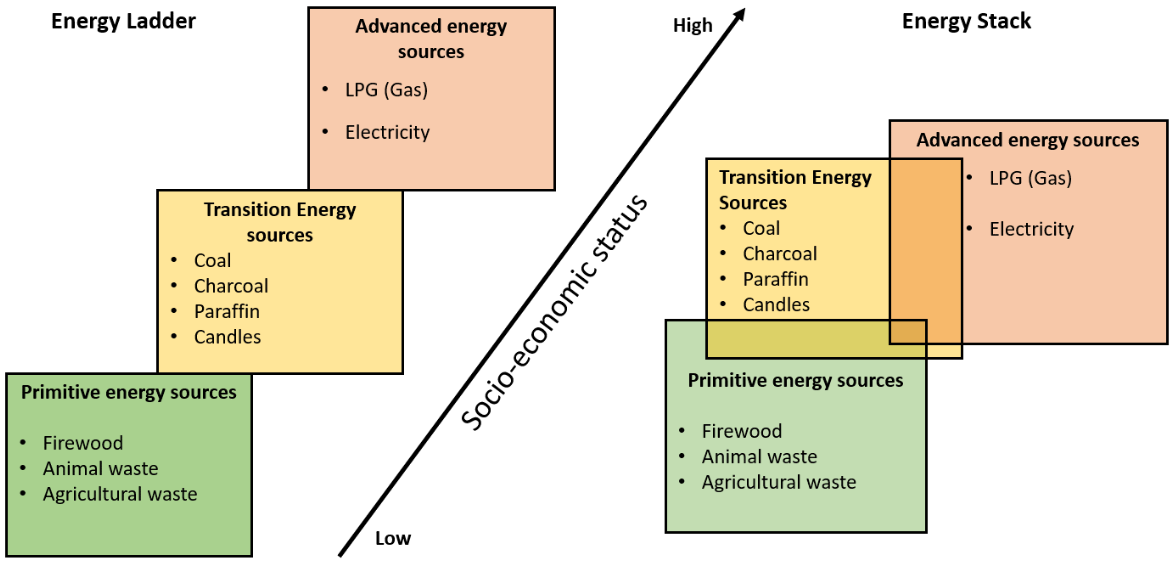


Figure 3 Energy transition process: Energy ladder model versus Energy stacking model (van der Kroon et al. 2011)

According to the Department of Energy's (DoE) 2012 *Survey of energy-related behaviour and perceptions in South Africa: the residential sector*, this energy stacking approach has been observed in many low-income households in South Africa (DoE 2012). For example, 54% of the 3004 households surveyed across the country utilised a mixture of electric and non-electric energy sources to provide lighting for the dwelling. Approximately a quarter of all households utilise a mixture of candles and electricity for lighting in their homes. Similarly, 48% of households rely on a mixture of electricity gas, paraffin and/or firewood for cooking purposes. Other reports found that during the South African winter, it was common for households to utilise paraffin as well as firewood and coal more frequently as households can use these sources to both cook, boil water and provide heat to their dwellings simultaneously (Mehlwana 1997; Truran 2009; Rogers & Mphande 2017). In particular, Truran (2009) observed that paraffin sales increased significantly between April and September each year as households sought more fuel to provide heat for their dwellings.

The DoE 2012 report observed that energy stacking was more prevalent among urban informal dwellings like BYDs and ISDs than formal households. For example, the report observed that 60% and 63% of informal households (including both ISDs and BYDs) use a mixture of energy sources for lighting and cooking respectively. Compared to 42% and 35% of formal households who use an energy mix for lighting and cooking respectively. Another observation made by the report was that energy stacking was commonly employed by households with low standards of living (RSA 2012b).

2.2.4 Factors influencing utilisation of energy stacking strategies by low-income households.

Household utilisation of a mixture of advanced, transitional and sometimes even primitive fuels is usually determined by one or a combination of the following three factors: issues of physical accessibility, financial limitations, and cultural preferences (van der Kroon et al. 2011; Truran 2009). Physical accessibility to 'modern' energy sources such as electricity or gas remains a critical issue for many low-income households across the globe. An estimated 1.2 billion people internationally, predominantly in developing states, were without access to electricity in 2016, and 2.7 billion people are still largely reliant on more non-electric based sources of energy generation to meet their needs as of 2016 (IEA 2014; Practical Action 2012). According to the 2014 Africa Energy Outlook report, more than 620 million people in sub-Saharan Africa (two-thirds of the population) live without access to electricity (IEA 2014). While most South African households have access to electricity, this does not necessarily mean that they have equal quality of access to electricity (SEA 2014; Mehlwana 1997).

As noted earlier, many BYDs and ISDs access electricity through informally constructed electrical connections, which are accessed with from a neighbouring electrified dwelling or illegally siphoned from electrical infrastructure such as an electric power box or power lines (Zweig 2015; Franks & Prasad 2014; Kovacic et al. 2016; Smith 2005). These electrical connections are shared among multiple households, creating huge pressure on wiring that is often inadequate to handle the demand (Mehlwana & Qase 1999). Therefore, such connections are prone to 'trips' if too many electrical appliances are being operated simultaneously. Such informal connections may also be unstable from a socio-political perspective. For example, those living in legally connected host dwellings may cut households access to power due to disagreements, non-payment or payment disputes (Franks & Prasad 2014). Eskom technicians also often dismantle the illegal connections and attempt to bar further access. Consequently, many of these informally connected households are forced to utilise an energy stacking approach, using non-electric energy sources such as paraffin, candles, gas and firewood at times as a 'back-up' or to reduce their energy demands (Hosier and Kipyonda, 1993; Zweig 2015).

While electricity is a more desired and efficient energy source, and is available to the majority of dwellings (through formal or informal means), many low-income households in South Africa struggle to afford electricity to meet their daily energy needs. There are a number of factors which influence their spending on energy sources. Low-income households may struggle to afford advanced energy sources because of their low, irregular and or variable income flows (Davis 1998; SEA 2014). For instance, recent research on living conditions in backyard dwellings in Cape Town, showed that BYDs are forced to pay high rates by their landlords for access to their electricity, limiting their use of electricity and potentially keeping their electrical usage constrained (Zweig 2015). This situation is particularly the case in larger households, which may struggle to purchase sufficient electricity (Kohler, Rhodes and Vermaak 2009; Kovacic et al. 2016; Ismail 2015). Zweig (2015:5) observed that it was not uncommon for BYDs to "survive on a low average household income, supported by a single bread-winner". Thus, households have to decide whether to spend more on energy sources to meet their daily needs or forgo other expenses such as food, transport and other daily costs, or spend less on energy and have an inadequate supply to meet their daily needs. Poor households' ability to afford their preferred energy sources, such as electricity, are particularly vulnerable to price fluctuations, making it too expensive to purchase (Hosier and Kipyonda, 1993; Winkler et al. 2011). Swart and Bredenkamp (2012) highlight that increasing electricity prices since 2007 have impacted low-income households significantly in South Africa. According to Eskom's data on its tariff history, electricity tariffs have increased by 300% between 2007 and 2015, compared to the 45% national inflation (Moolman 2015; Eskom 2017).

The cost of purchasing electronic appliances may also serve as a barrier to the use of electricity (Louw, Conradie, Howells & Dekenah 2008; Lloyd 2014b). Appliances such as electric stoves, ovens and refrigerators generally have higher set up costs than non-electric ones, and it may take several years for such households to be able to save up and afford to purchase such appliances. Consequently, it is common for households to purchase energy sources such as paraffin, candles, gas and biofuels as cheaper alternatives for activities such as cooking, lighting, boiling water and heating of homes (Swart & Bredenkamp 2012; Balmer 2011). Lloyd (2014b) observes that the switch from using electricity to non-electric sources often occurs when money is short, especially towards the end of the week or month, before salaries are paid. These periods are known as 'skip days' (or even 'skip weeks') during which the household will 'skip' using electricity for a time to save money and purchase or borrow alternative energy sources (Ruiters 2008). Paraffin, in particular, is relatively accessible and affordable and can be bought from the local 'spaza' shops (informal convenience stores that operate from a room in a house where basic goods and services such as airtime for mobile phones and electricity can be purchased) (Louw et al. 2008; Panday & Mafu 2007), and can be purchased in small quantities, even in 'cupfuls'. Paraffin may cost anything between R4 and R8 per cup, depending on the amount, the vendor and the time of the year (Lloyd 2014b; Rogers & Mphande 2017). Often spaza shops allow households to buy paraffin on credit, to be paid back at the end of the week or month when the household member is paid. Paraffin is also considered a 'social fuel' as it can be easily borrowed by neighbours if they run short (Lloyd 2014b; Truran 2009). Other energy sources, such as firewood, coal candles, and in some instances gas, can also be borrowed.

Swart and Bredenkamp (2012) argue that households may use multiple fuel use because of cultural or behavioural preferences. Households may prefer to use firewood or coals to cook their foods because they are more used to cooking in that manner and feel more confident using it than other energy sources and appliances (Balmer 2011). Fuels like firewood are often used during traditional ceremonial events or special occasions, in which households cook traditional meals, or for large numbers of people, using a *braai* and grill (Mehlwana & Qase 1999). It has been observed that older non-electric or 'traditional' energy sources such as paraffin, coal and firewood have become a permanent feature of poor households' identity and culture, especially among older pre-electrification generations (Panday and Mafu 2007; Mehlwana 1997), who may be less willing to embrace energy sources such as electricity or gas.

2.3 ENERGY-RELATED FIRE RISKS EXPERIENCED BY LOW-INCOME HOUSEHOLDS

There has been increasing recognition that low-income communities and households in urban areas, such as those living in informal dwellings, are exposed to and experience frequent hazards, which threaten to negatively impact their livelihoods and undermine development (UN-Habitat 2015b). Dwelling fires pose a significant threat to poor urban populations, and are often ignited by energy sources such as paraffin stoves and candles. Paraffin, firewood, coal and candles also produce emissions which are potentially hazardous to household members. Thus, the households' energy choices pose a significant threat to their assets, wellbeing and livelihoods (Lloyd 2014a; HESASA 2013a).

Dwelling fires are an ongoing challenge for urban residents across South Africa (Pharoah 2009, Pharoah, Fortune, Chasi & Holloway 2013). A significant proportion of these fires have occurred in informal settlements, although with increases in the number of BYDs, there is growing focus on formal low-cost housing areas. In Cape Town, over 16 000 residential fires were reported by emergency services between 2009 and 2016, of which 7605 (47%) were in informal dwellings (Western Cape Government 2017). Community risk assessments, primarily in informal settlements, also identify fires as a common hazard. These assessments, undertaken by the Disaster Mitigation for Sustainable Livelihoods Programme (DiMP) – renamed to the Research Alliance for Disaster and Risk Reduction (RADAR) in 2013 – found that people living in these communities exist in a constant state of fear that they could lose their dwelling, possessions and even incur injury or death from fires (DiMP 2010; DiMP 2011; DiMP 2012; RADAR 2014).

These fires are often attributed to accidents involving the usage of non-electric energy sources and appliances (Western Cape Government 2015; Truran 2009). Candles are a commonly blamed for residential fires, especially in informal dwellings (CoCT 2015; Harte, Childs & Hastings 2009). According to research by Swart and Bredenkamp (2012), they estimate that approximately a third of all informal dwelling fires in South Africa are caused by candle-related accidents. Often candles are knocked over accidentally by people, the wind or have something such as a curtain or clothing coming into contact with the flame (Swart & Bredenkamp 2012; Greeff & Lawrence 2012). People may even fall asleep, forgetting to put the candle out, allowing the candle to burn unattended. Paraffin is also considered responsible for many fires in residential areas. Paraffin is highly flammable and has a low flashpoint (lowest temperature at which an object/substance can ignite when given an ignition source) of 43ºC allowing it to ignite very easily (Truran 2009; Panday & Mafu 2007; Lam et al. 2012). A paraffin-based fire can reach a temperature of 400ºC in under a minute (Lloyd 2014b; Schwebel, Swart, Hui, Simpson & Hobe 2009). The radiant heat produced can easily ignite nearby materials, furniture and spread to other structures.

The Paraffin Safety Association of South Africa (PASASA) estimates in 2012 that about 56% of dwelling fires in South Africa were attributed to paraffin-related ignitions (Lloyd 2012; Swart & Bredenkamp 2012). Fires have been known to start from accidentally knocking over paraffin stoves or leaving them unattended for too long (Paulsen 2010; Rosenberg 2013; Kimemia & van Niekerk 2017). According to Lloyd (2012), paraffin stoves have been known to spout out flames or 'explode', causing instantaneous damage and a fire that is almost impossible to put out. Such 'explosions' can occur because of either contaminated fuel or faulty, poor-quality or worn out appliances. According to Schwebel et al. (2009) it is not uncommon for paraffin to become contaminated with other liquids, either from informal vendors intentionally diluting it with water or petrol, or users accidentally contaminating their paraffin while transporting it in cups or bottles that previously held another liquid such as water or petrol. Such contamination changes the paraffin's chemical composition, making it more volatile when heated (Lloyd 2014b; Schwebel et al. 2009; Panday & Mafu 2007). Fires have also been started due to worn out or faulty paraffin stoves such as the overheating of fuel tanks and corroding of mechanisms. According to Lloyd (2014b), a number of illegal paraffin stoves which failed the South African Bureau of Standards safety standards have been found circulating among the black market, being sold to people who are unaware of the deficiencies of these cheaply made appliances.

Although gas is a relatively underused energy source in South Africa, it too can cause fires. Gas is also highly flammable and prone to cause fires if used improperly (CoCT 2015; Mohlakoana & Annecke 2008; Lloyd 2012; Lloyd 2014b). Gas fires usually involve households either forgetting to, or incorrectly switching off the gas. As with paraffin, fires are also associated with faulty appliances. In June 2017, for example, 1000 Bosch gas cookers were recalled due to the 'potential risk of explosion' related the faulty connecting pipes (Knowler 2017). It is interesting to note that several authors have observed that low levels of gas usage in South Africa stem from people's perception that it is highly dangerous, despite efforts by local government and local gas suppliers to promote it as a clean, controllable, efficient and safe form of energy (Mohlakoana & Annecke 2008; Lloyd 2012).

It has often been reported that a number of fires among low-income households are linked to negligent, irresponsible or anti-social behaviours. Truran (2009:9) believes that while particular energy sources can be viewed as hazards that may cause fire, the real "danger is not so much paraffin per se but rather the unsafe system of paraffin use". Other research has linked causes of dwelling fires to drunken behaviour, such as people returning home from a night of drinking attempt to either light a candle or cook in their inebriated state (Pharoah 2009; Harte, Childs & Hastings 2009; Western Cape Government 2016), or they fall asleep leaving a flame unattended. Increased frequency or 'spikes' of fire incidences have been known to occur during holidays such as the festive season and New Year because people tend to drink more often, hence are more likely to cause accidents leading to fire (Pharoah 2009).

While energy sources such as paraffin or candles are frequently blamed for fires, ignitions caused by faulty electric appliances and infrastructure are not uncommon (Albertyn, et al. 2012). With increasing access to electricity has come an increase in fires started by electronic appliances and faulty wiring (Lemaire 2015; Rosenberg 2013). The City of Cape Town's data on fire incidents between 2009 and 2015 suggests an increasing number of fires initiated by electronic appliances and infrastructure, as shown in Figure 4 (Western Cape Government 2017). The data shows that while electric-based fires have increased by 132% among formal dwellings during this period, such fires have increased by 334.5% among informal dwellings[1]. It was also observed from the city's data that the proportion of residential fires caused by electricity in Cape Town has increased from 10.9% in 2009 to almost 25% of all residential fires by the end of 2015 (ibid).

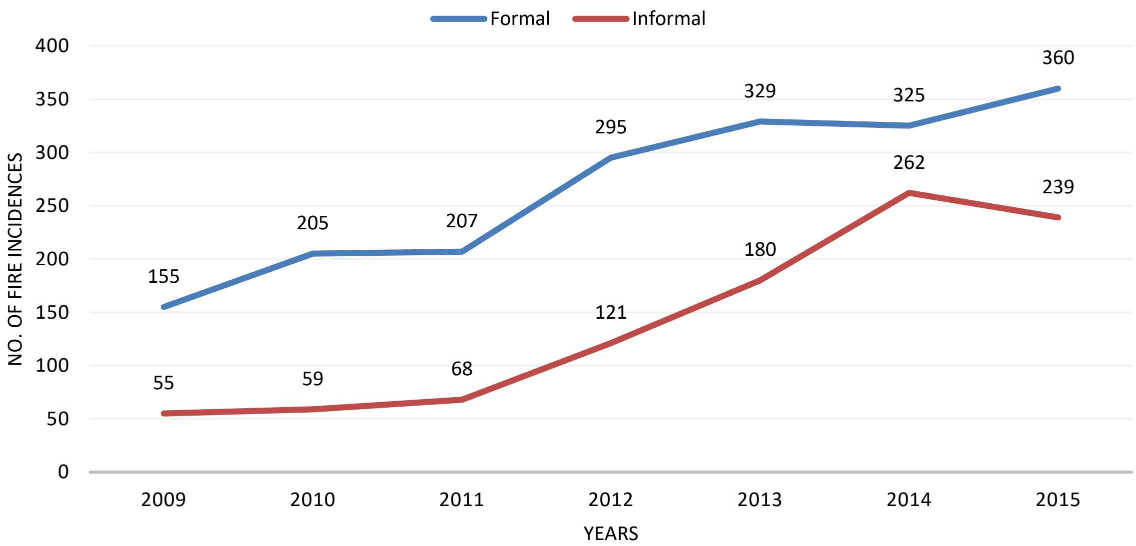


Figure 4 Increase in electric-based fires among dwellings in Cape Town between 2009 and 2015 (Western Cape Government 2017).

[1] The data did not differentiate between ISDs and BYDs, but grouped them as informal dwellings

Electricity-ignited fires are commonly caused by either faulty electric infrastructure, or outlets, cords or devices, which either overheat or cause sparks, setting fire to nearby flammable materials such as furniture, carpets, clothing and curtains (FireRescue1 2016; USFA 2017). Zweig (2015) observed in her research on BYDs that informal connections between the BYD and landlord's dwelling pose a significant fire risk to both dwellings. Fires can be caused by utilising too many electric appliances at once which may cause wires and plug points to overheat and or cause sparks (Rosenberg 2013; Lemaire 2015). It has also been observed that exposed wiring in informal connections among BYDs or ISDs may also cause sparks if exposed to water (Pule 2014). Fires can also result from accidentally leaving electric appliances on. A prime example comes from a fire report from the CoCT fire incident data (2017): a man residing in an informally connected BYD in Masiphumelele tried to cook breakfast on his electric stove, however, the landlord had run out of electricity the night before and had not recharged it. The man left to work, forgetting that he had left the stove in the on position. During the day, the landlord returned and recharged his electric meter; the stove overheated in the dwelling, igniting materials in the BYD and caused a fire which destroyed both the BYD and landlord's dwelling.

3 OVERVIEW OF RESEARCH METHODOLOGY

3.1 INTRODUCTION

This section of the thesis provides an overview of the approach and methods used to gather, consolidate and critically analyse the data collected during the research. This overview includes describing scoping research, the selection of study sites, the types of data and the approach to data collection and how the information was captured, interpreted and analysed. The research adopted a stepped approach, which included initial scoping research to identify literature, sources of data and key issues to be explored during the research.

3.2 SCOPING PROCESS

Initial scoping for this thesis focused on collecting and analysing information concerning energy usage, energy-related hazards and dwelling fire incidents in Cape Town. This included:

i. A review of literature, including journal articles, reports and research by governmental and nongovernmental institutions and newspaper articles on issues concerning household energy choices, energy-related hazards and reported dwelling fires.
ii. Semi-structured interviews with local stakeholders, including representatives from local disaster management and the fire and rescue service (particularly the Helderberg district of Cape Town), personnel from the City of Cape Town's Department of Human Settlements and Department of Electricity, as well as staff of the Lwandle Migrant Labour Museum. These interviews will be discussed further in section 3.3.1.
iii. Analysis of secondary data, such as the fire incident data from the City of Cape Town to analyse the information on number, location and cause of ignition for dwelling fires in the Cape Town Metro. It was initially envisaged that the research would collect data on and compare reported fire incidents and the roll-out of electricity services over time and geographical area, in order to explore whether greater access to electricity has had any effect on fire rates in the metro. Unfortunately, although Eskom, the Human Settlements Department and city authorities were approached, these efforts were unsuccessful, both due to the alleged sensitive nature of the data and authorities' reluctance to make data available for research purposes.

These sources provided insight into the issues and challenges associated with energy usage and associated fire risk in low-income residential areas, and served to inform and guide the subsequent research, along with helping to identify potential sites to conduct research for this thesis.

3.3 SELECTION OF STUDY SITE

The residential suburbs of Lwandle, Nomzamo and Asanda Village, close to Somerset West and Strand within the City of Cape Town Metropolitan area, as shown in Figure 5, were selected as the study site for this research.

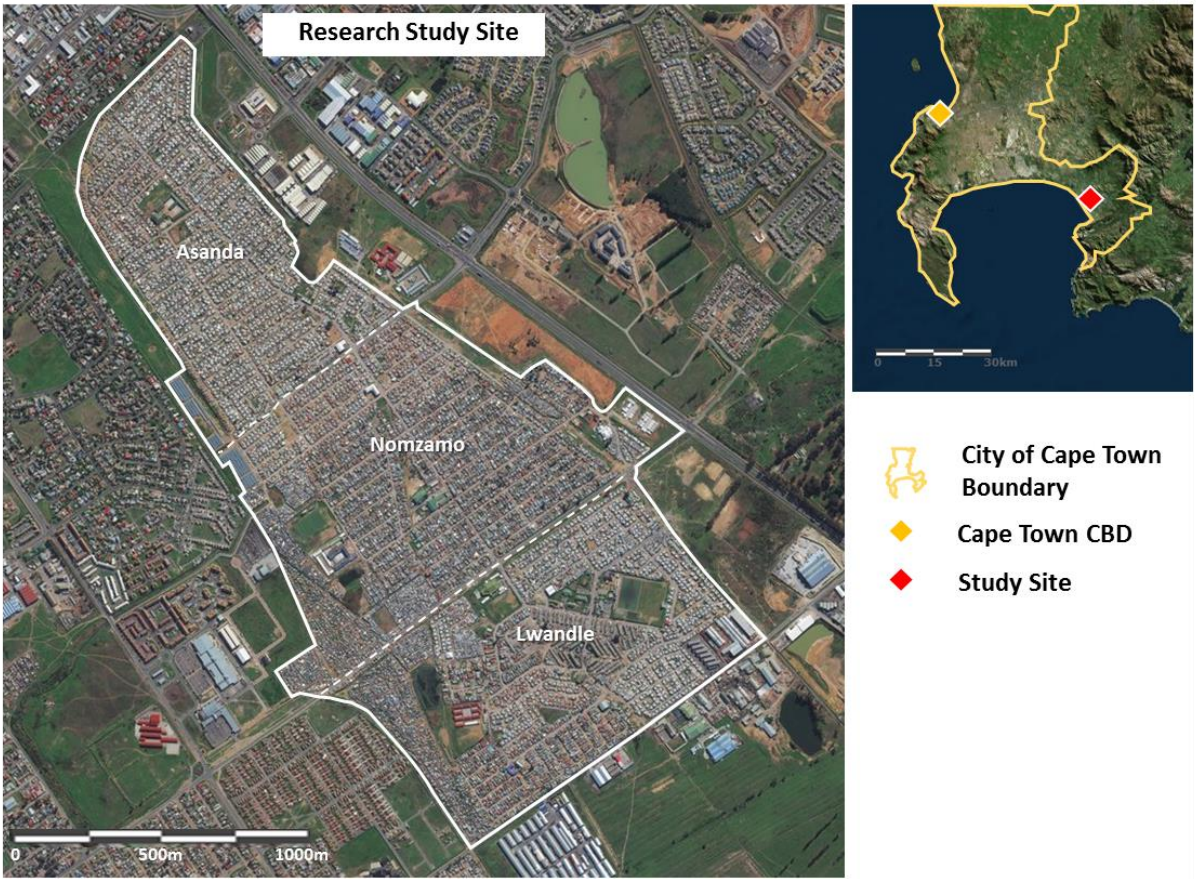


Figure 5 Map of the study site and map of the study site in relation to Cape Town

The rationale for their selection as study sites was based on the following factors which made it an ideal group of settlements and communities to conduct research in:

- The majority of households in the site earn a low-income (i.e. under R5000 per month) according to 2011 census data of the suburbs. Lower income households are known for having more diverse energy use strategies than higher income households.
- The site exhibits a diversity of residential dwelling types. These include hostels, government built formal low-cost housing – so called 'RDP' houses – often accompanied by one or more backyard dwellings, as well as stand-alone 'shacks' in informal settlements.
- The site exhibits a mixture of formal electrical access (legally installed infrastructure and electricity meters) and informally constructed illegal connections, which tap electricity from neighbouring electrified dwellings or from electric infrastructure such as power lines and sub-stations.

- The site has a history of dwelling fires, with both fire incident data and newspapers recording repeated and severe fires.

3.4 QUALITATIVE PRIMARY DATA COLLECTION

Within the study area, the research gathered both qualitative and quantitative data, the latter collected through a household-level community survey. The qualitative primary data was gathered through focus groups and in-depth interviews with local stakeholders to discuss issues concerning local energy usage and the associated fire risk. The qualitative data was used to both inform the design of the survey questionnaire, and provide insight into the survey results during the analysis of the data.

3.4.1 Discussions with key stakeholders

Key stakeholders were consulted with to attain a more general community-based perspective of the energy-related issues experienced by the residents of Lwandle, Nomzamo and Asanda Village. Staff members from the Lwandle Migrant Labour Museum provided historical information of the settlement, including its origins and growth over time, as well as insights into the contemporary context, particularly regarding household energy choices. The staff assisted in identifying areas of relevance to the study, such as those households with limited or no formal access to electricity. Ward councillors for Lwandle and Nomzamo provided insight into energy provision and accessibility within the area and the sometimes tense relationship between the residents and local government and service providers concerning distribution of electrical infrastructure and services. Officials from the City of Cape Town's electricity department were interviewed to discuss the electrical services and infrastructure that are currently in place in the study site, as well as what challenges that exist in the upkeep and expansion of this infrastructure. The fire chief of Strand fire station, along with the district disaster manager for Somerset West were interviewed to discuss household energy usage and occurrence of fire incidences within the study site.

3.4.2 Door-to-door interviews with residents

Door-to-door interviews were also conducted with 60 households to explore what types of energy they utilised, whether they perceived them as a fire hazard and whether they have experienced a dwelling fire initiated by an energy source in their dwelling. Data from these households was transcribed from field notes.These interviews, like the stakeholder discussions, assisted in identifying issues for investigation in the household survey. Interviews were divided by dwelling type, with 20 households in formal dwellings, BYDs and ISDs being interviewed each. These households comprised a random convenience sample depending on the residents' willingness to participate in the interview. The interviews were semi-structured with several themed questions prepared in advance (see example in Appendix B) while other spontaneous yet related questions arose depending on the responses of the resident. The majority of residents interviewed could not speak English fluently so a translator was employed to assist in explaining the researcher's questions and translating residents' responses. Duration of interviews was usually between 15 to 25 minutes, depending largely on the enthusiasm of the resident/s during these sessions and whether they gave long descriptions which needed to be translated. These interviews partially sought to ascertain whether their experiences were similar or different to those recorded in previous research and reports.

3.4.3 Focus group sessions with residents

With the assistance of the ward councillors of Lwandle and Nomzamo, eight focus group sessions were conducted in which residents of Lwandle, Nomzamo and Asanda Village were invited to discuss and debate issues regarding energy usage. The residents from each area were separated into three specific dwelling-based focus groups, as demonstrated in Table 2 below.

Table 2 Dates and times of the various focus groups held in the study site.

Date	Focus Group	Time
26 April 2017	Formal dwelling residents of Nomzamo	9:00 – 11:00
	BYD residents of Nomzamo	11:00 – 12:30
	ISD residents of Nomzamo	13:30 – 15:15
27 April 2017	Formal dwelling residents of Lwandle	10:00 – 11:30
28 April 2017	BYD residents of Lwandle	9:00 – 11:00
	ISD residents of Lwandle	11:30 – 13:15
2 May 2017	Formal dwelling residents of Asanda Village	9:00 – 11:00
	BYD residents of Asanda Village	11:30 – 12:50

The researcher facilitated each of the focus groups. Two or three assistants were present at each focus group to provide assistance in setting up and translation. Focus groups lasted between 90 minutes and two hours, depending on the level of engagement by participants. Selection of participants for these sessions was random as they were open for residents to attend. Many of participants were either friends, neighbours or family members of the ward councillors, Lwandle Museum staff and research assistants who were tasked with advertising and inviting residents to attend. The number of participants varied, ranging between 12 and 25 people. It was noted that middle-aged women made up the majority of attendees at each session. This was most likely because most women were unemployed and remained in the settlement during the day. These participatory focus groups sought to identify significant fire events, energy use preferences for particular activities, the positive and negative attributes of energy sources and strategies to reduce the risk of fires. Example outcomes of these exercises are illustrated in Figures 6-9, below.

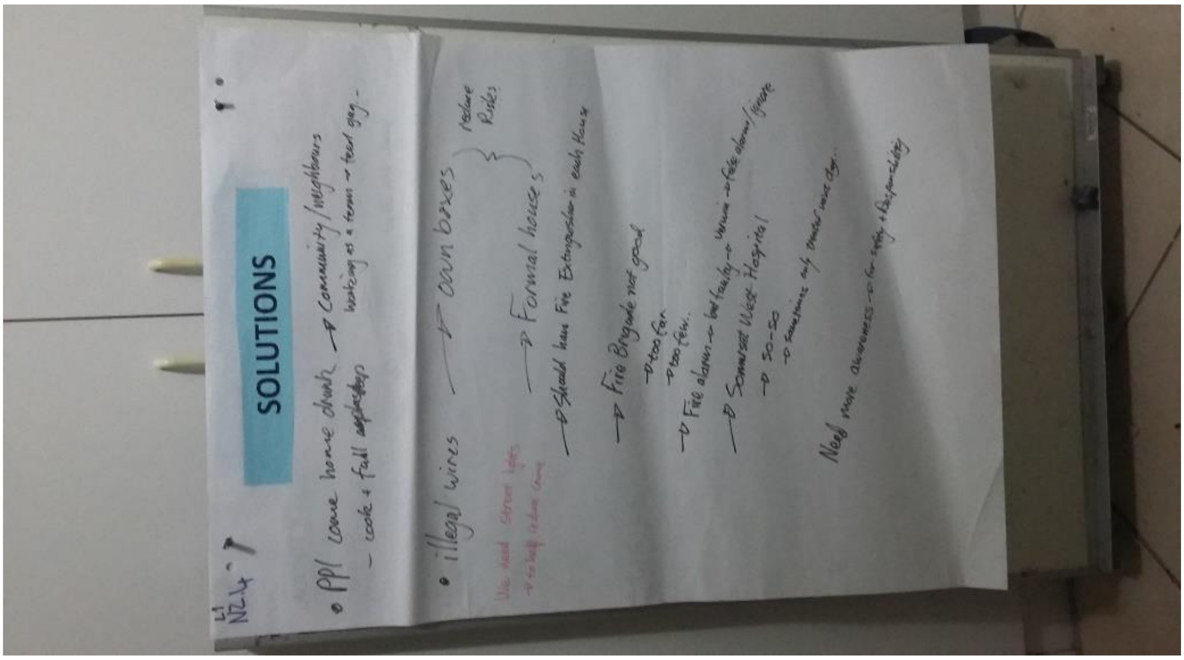


Figure 6 Chart documenting solutions to reducing negative impacts of energy sources

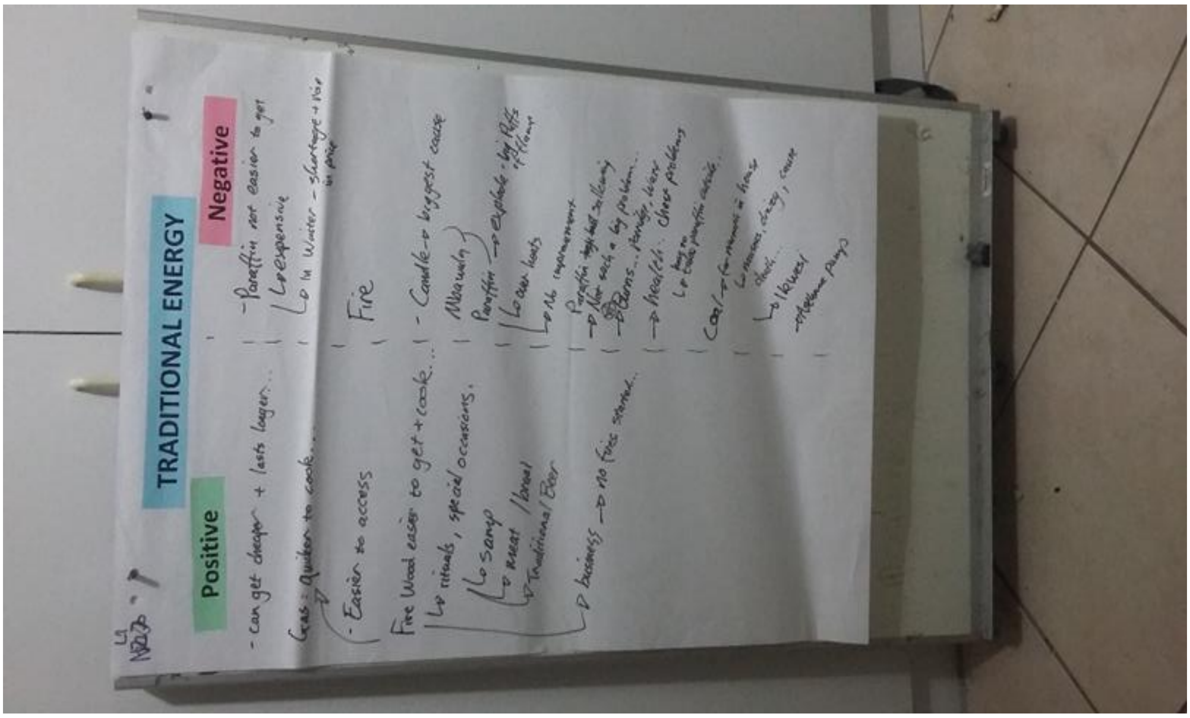


Figure 7 Chart dcumenting positive and negatives of traditional/non-electric energy sources

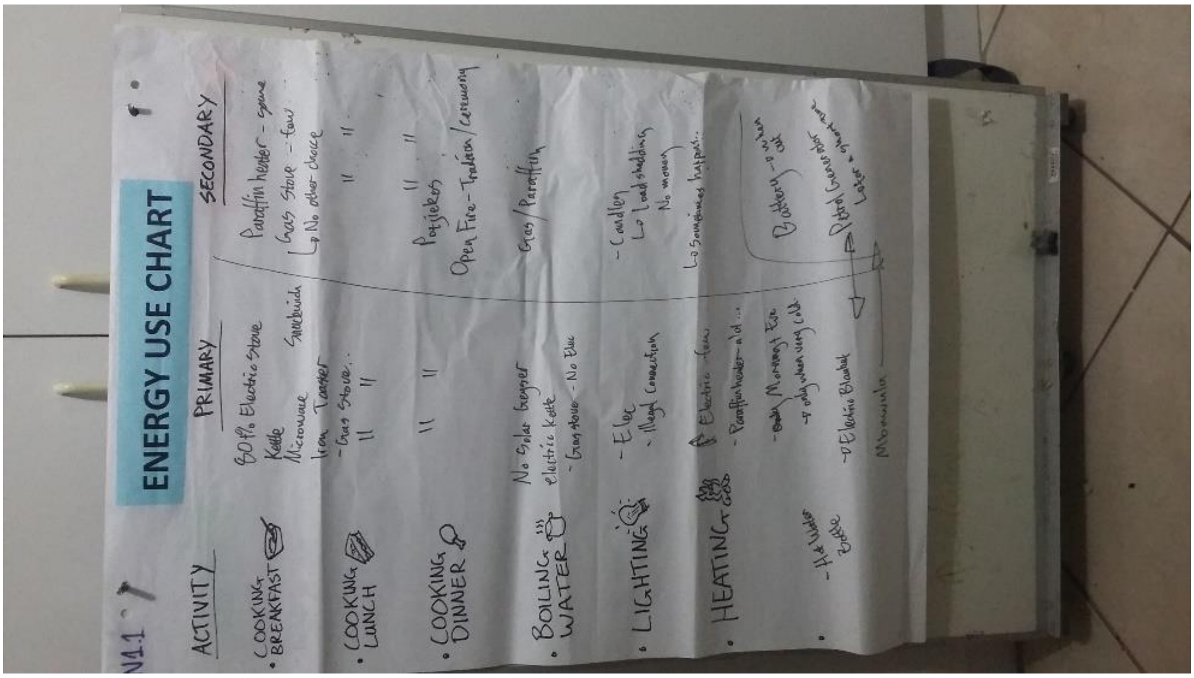


Figure 8 Energy Use Chart to document different energy sources used for different activities

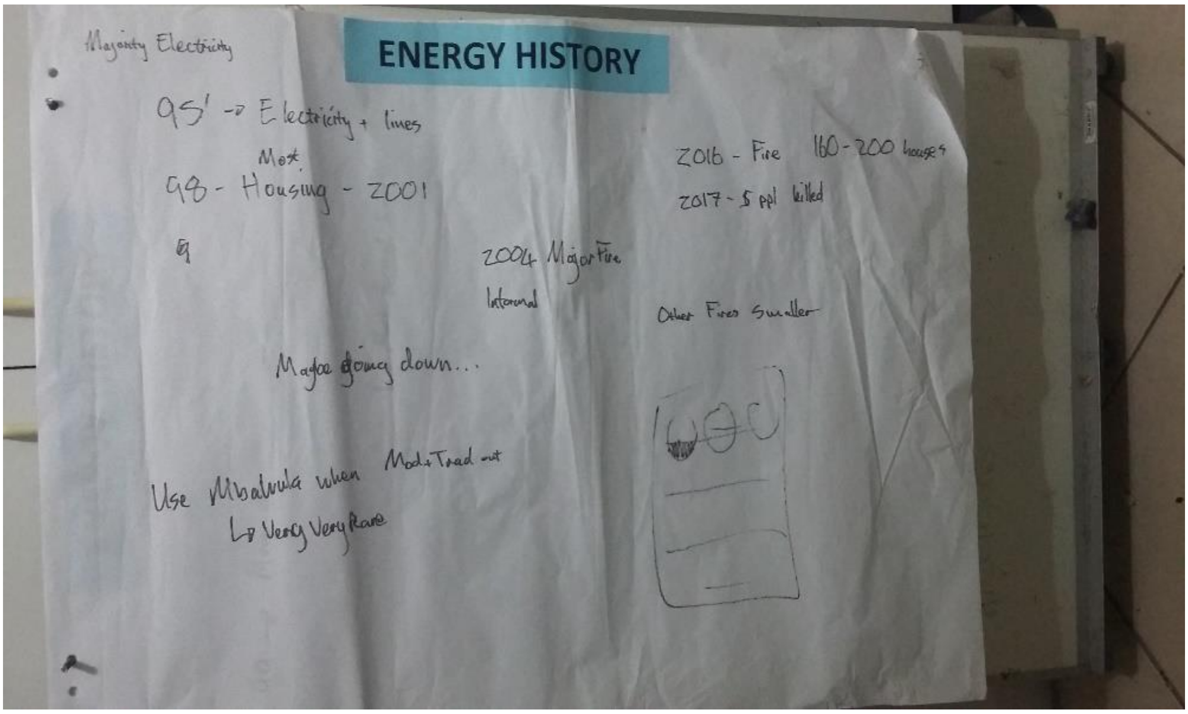


Figure 9 Energy History Chart to document changes in energy usage over time

3.5 QUANTITATIVE PRIMARY DATA COLLECTION

Drawing on the insights and perceptions collected in earlier phases, a household survey was designed to gather quantitative data concerning household energy usage and perceived fire-risk. A copy of the questionnaire can be seen in Appendix A. In total 650 questionnaires were distributed, with 530 being consolidated for the thesis findings. The survey was predominantly comprised of pre-coded closed-ended questions but also included open-ended questions, allowing participants to provide their own in-depth explanation and feelings on a particular issue. Participants could refuse to answer any question if they wanted to.

3.5.1 Survey pilot study

Before distributing the survey, a pilot version was developed and administered to 50 households in Lwandle and Nomzamo to test questions and refine codes. The pilot study highlighted questions that confused respondents, and after deliberation with the research assistants, the questions were reworded to improve comprehension, and assistants for the main survey were trained to address questions that could be unclear or confusing to participants.

3.5.2 Survey sample size and participant selection

Unfortunately, there is little data on the number of households or the proportion of different dwelling types in the three suburbs of the study site, for example there was no data that stated the number of ISDs, BYDs and formal dwellings in Lwandle and Nomzamo respectively. Therefore, one could not estimate the number of participants that would be necessary for the quantitative survey to attain results that reflect the specific population groups (i.e. formal dwellers in Nomzamo) as precisely as possible. Therefore, it was decided to determine the size of the sample for the survey based on the number of 'households' within the study site as a whole which according to the 2011 South African census data was 19520 (RSA 2012a). Consequently, an online sample size calculator offered by Creative Research Systems (CRS) (https://www.surveysystem.com/sscalc.htm#one) was utilised. According to the CRS calculator, a sample of 644 households would needed to achieve a 99% confidence level with a 5% confidence interval among a population of 19520 households within the study site. Participating households within each study site were selected through a stratified sampling technique, in which households were divided into three subgroups based on dwelling types (formal, BYD and ISD), with participants randomly selected from each group to contribute towards the research (Babbie 2010; Sagepub 2010). Participating household members needed to be over 18 years of age and must have lived in the study site for no less than one year.

3.5.3 Survey implementation

The survey was conducted in May 2017, by the researcher and eight research assistants. The local research assistants were advantageous to the survey distribution and data collection as they knew the settlement well, they could speak IsiXhosa and English fluently, allowing for translation if need be, and were more easily welcomed by participating households. The research assistants were selected with the aid of the manager of the Lwandle Migrant Labour Museum with three being chosen from Lwandle, three from Nomzamo and two from Asanda. Each research assistant was tasked with completing 75 surveys. Questionnaires were expected to take 20 – 30 minutes to complete, however many of the research assistants found themselves taking up to 40 minutes. The questionnaires were collected and checked every second day to ensure that surveys were completed correctly, and to identify errors that needed to be addressed. In total, it took just over two weeks to have all the assistant researchers complete and hand in their allotted questionnaires.

Of the 650 questionnaires that were printed and distributed (these included the 50 questionnaires that were used during the pilot study), only 530 were returned and sufficiently completed to be captured for analysis. While 45 questionnaires had errors that made them ineligible for data capturing, another 75 were never returned because the assigned field research assistant did not complete or return their allotted questionnaires. Of the 530 households which participated in the household survey, as shown in Figure 10, approximately 54.3% of households surveyed resided in formal dwellings (these included both RDP and hostel dwellings), 27.9% within BYDs, 17.7% within ISDs.

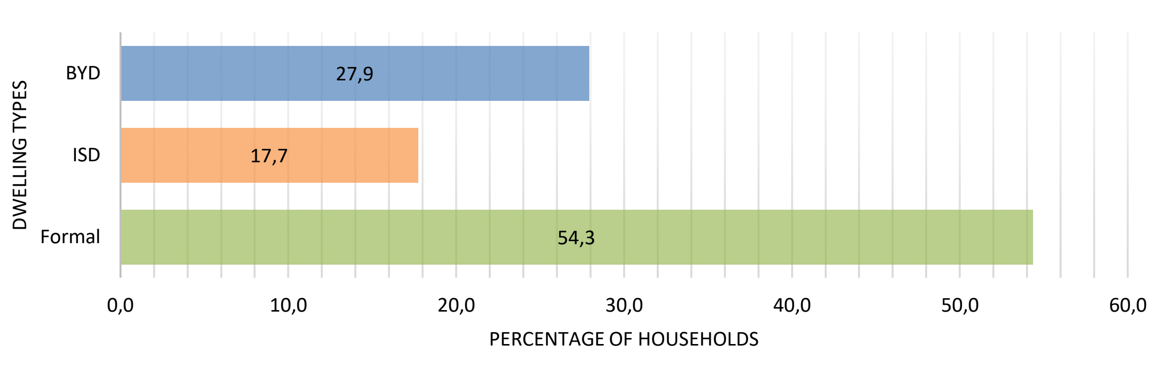


Figure 10 Percentages of households surveyed by dwelling type (n=530)

3.6 PRIMARY DATA CONSOLIDATION AND ANALYSIS

The quantitative data was captured in SPSS, while the qualitative data was organised thematically and used to interrogate the quantitative results. The findings and insights from both the qualitative and quantitative components were analysed to identify any thematic trends, potential relationships and both convergence and divergence from the literature.

This data, particularly the graphs, were presented back to the research assistants, the ward councillor of Nomzamo and about 10 members of the study site to acquire feedback on the emerging results from the focus groups, interviews and surveys. In particular, this feedback was useful for attempting to understand and rationalise data that did not appear to make sense i.e. bars within graphs that appeared to contradict findings from the qualitative research. These feedback sessions were vital in ascertaining some of the findings acquired, clarifying several confusions as well as highlighting new and interesting issues and insights that had not been picked up during the data collection.

3.7 ETHICAL CONSIDERATIONS FOR THE RESEARCH

- **Consent from the participants:** The Researcher and research assistants ensured that participants fully understood the purpose of the research, had verbally consented to being part of the research and were willing to share their knowledge, experiences and perceptions. Participants could opt out of the research at any point.
- **Anonymity of participants:** The researcher ensured that all participants and their data were kept anonymous and privacy respected. All data shared was confidential.
- **Research participants not to be subjected to any form of discomfort or harm:** The researcher was mindful that some of the participants may have been affected by fires, and may have found discussing the subject and related matters difficult, uncomfortable of even painful. The researcher and assistants were aware and sensitive to such issues when designing questions and engaging with participants.
- **Researcher and assistants' safety of paramount importance:** The research was conducted in areas with high criminal activity. It was important that the researcher and assistants were careful, vigilant and not make themselves a target. This included limiting valuable possessions on their persons while in the field, and being accompanied by a member of the community at all times. If the researcher or assistants ever believed that their safety was in jeopardy they were told to leave the area and continue working elsewhere.
- **Avoiding inaccurate, misleading or biased representation of research and findings:** During data analysis, the researcher thoroughly analysed the data and information acquired in the field, identifying inaccuracies, and discrepancies. When possible the researcher would attempt to correct or rectify such issues by either following up with research assistants or participants. If this was not possible, such data was removed from the analysis. The researcher endeavoured to ensure that the data received from participants was portrayed as faithfully as possible. The researcher also endeavoured to ensure that none of his own personal biases were portrayed while interpreting and presenting the data. One way the researcher attempted to avoid his own bias was by presenting the research findings to community members involved in the research for their input and suggestions.

3.8 LIMITATIONS IDENTIFIED IN THIS RESEARCH

There were several limitations experienced while conducting this research. The limitations included:

- **Inability to access data and information**: As noted earlier, attempts were made to obtain statistical and spatial data on the roll-out of electrical infrastructure, but the authorities viewed such data was considered sensitive and unavailable to the public. This prevented the researcher from obtaining information such as the extent of formal electrification in the study site, the number of electrified dwellings, the areas that are formally electrified and when (formal) electricity was provided. Such information could have provided assistance in selecting households for data collection, as well as greater understanding regarding the past and contemporary energy situation in the study site. Difficulties were also experienced with respect to data on housing statistics for the research site, such as when housing was built. Data on basic infrastructure provision was also unavailable.

- **Issues of translation during interviews and focus groups**: The majority of residents engaged with during interviews and focus groups had either no or very limited understanding of English, hence a translator was needed for such sessions. Sometimes the translator found it difficult to convey complex themes from the researcher to participants and vice versa. These translation issues also reduced the momentum of discussion and reduced the time available for discussion.
- **Representation, subjectivity, human error and biased information:** while acquiring information from communities in the form of residents' knowledge, experiences are opinions provides critical insight, the information may not be representative of communities as a whole. Qualitative data, especially acquired from focus groups, may be more reflective of some people's experiences than others. Convenience sampling also means that the data collected may not be representative of communities as a whole. Finally, answers are often subjective, influenced by perceptions and beliefs, and not necessarily by facts or evidence. Some residents were uncertain about particular questions, being unable to recall readily issues such as the cause of fires or monthly expenditure on particular energy sources. Some residents also attempted to provide misleading information, such as stating that they do not have access to electricity, despite evidence of electric appliances in their dwelling. The researcher attempted to identify and remove as much biased or potentially misleading information as possible, but some may remain in this report.
- **Safety of Research Assistants**: Originally, it was planned that a greater number of surveys would be distributed and completed by households living in ISDs, however, several of the research assistants stated that they did not feel safe conducting research in the informal residential areas hampering data collection. Some reported hostility from residents because they were asking questions concerning their supply of electricity (which was mostly informal and illegal). This meant that less quantitative data was collected from households living in ISDs.

4 BACKGROUND TO STUDY SITE

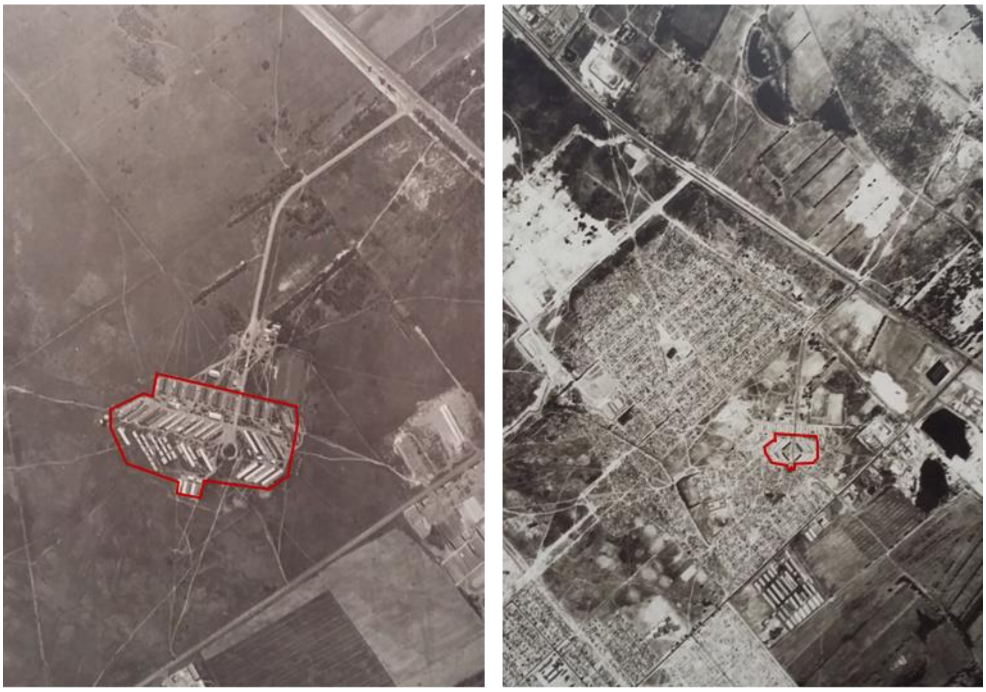
4.1 INTRODUCTION

This section introduces the study site used in this thesis. The site comprises the townships of Lwandle, Nomzamo and Asanda Village situated west of Cape Town within the City of Cape Town Metropolitan Municipality. The sites lie adjacent to the N2 national highway, between the towns of Somerset West and Strand, as depicted in Figure 11 below.

Figure 11 Map of the study site in relation to Cape Town

4.2 HISTORICAL BACKGROUND TO STUDY SITE

Lwandle was originally established in the 1950s. It initially comprised a group of dozen hostel buildings, created to accommodate some 500 Black male migrant labourers who worked on the neighbouring farms and towns, as can be seen in Figure 12 (1977) (Witz 2011; Soko pers. comm. 2017). These original hostels were provided with the barest of energy services, forcing inhabitants to utilise non-electrical energy sources such as candles and paraffin for lighting and cooking. Lwandle grew rapidly during the 1980s with the rolling back of apartheid system and the arrival and settling of migrants on the urban periphery of Somerset West and Cape Town. During this period, Lwandle grew to over 3000 people, many of these newly arrived migrants being the wives and children of the workers residing in the hostels. Living space in the hostels was limited, confined and unsuitable for families (Soko pers. comm. 2017). Consequently, hoping to relieve the pressures on these people, the government began to construct several thousand new formal dwellings next to Lwandle and thus establishing the township of Nomzamo, as can be seen in Figure 12 below, showing the extent of the expansion by 2000. Between the early 1990s and 2000s, both settlements grew enormously as more migrants arrived and settled themselves on available land. Government initiated formal housing projects and major service provision between the late 1990s and 2004. The last of these housing projects included the development of Asanda Village, built on unsettled land west of Nomzamo from 2006-2008.



Lwandle Migrant hostel units site 1977 Lwandle expansion 2000

Figure 12 Growth of Lwandle and Nomzamo (source – Lwandle Migrant Labour Museum)

4.3 CONTEMPORARY CHARACTERISTICS OF DWELLINGS AND HOUSEHOLDS WITHIN STUDY SITE

According to the 2011 national census, approximately 61 000 people reside within the three townships, compromising of some 19 520 households altogether (RSA 2012a). Over 90% of residents are Black South African, the majority of which speak isiXhosa as their first language. As depicted in Figure 13, the study site has a mixture of dwelling types which include:

- **a.** The original hostel dwellings which have been converted from dormitory-like halls into individual two roomed dwelling units. These halls are found almost exclusively in Lwandle, with a few hostel-like residential units situated in Nomzamo. These hostel dwellings are demarcated in red on Figure 13 below;
- **b.** Formal dwellings, most of which were built by the government in the early to mid-2000s. Several of these dwellings have been modified with additional rooms and levels added by the owners over time. According to the 2011 census, these dwelling comprise 63.2% of all residential

dwellings (RSA 2012a). These dwellings have not been demarcated by any particular colour in Figure 13 as they are found across the study site;

c. Informal Backyard dwellings (BYDs) which are situated on the property of formal dwellings and rented out by the owners of these properties. Usually these BYDs are constructed from wood, corrugated iron and plastic. There are currently no statistics or estimations on the number of BYDs located in the study site. These dwellings have not been demarcated by any particular colour in Figure 13 as they are found across the study site; and

d. Informal settlement dwellings (ISDs), commonly referred to as shacks, are located on the southernmost sections of the study site. These are identified on Figure 13 above with yellow outline. Tenureship of some of these dwellings to the south west of the study site is uncertain as they are located on land which has been earmarked for the development of a national highway (Davis 2014; News24 2014).

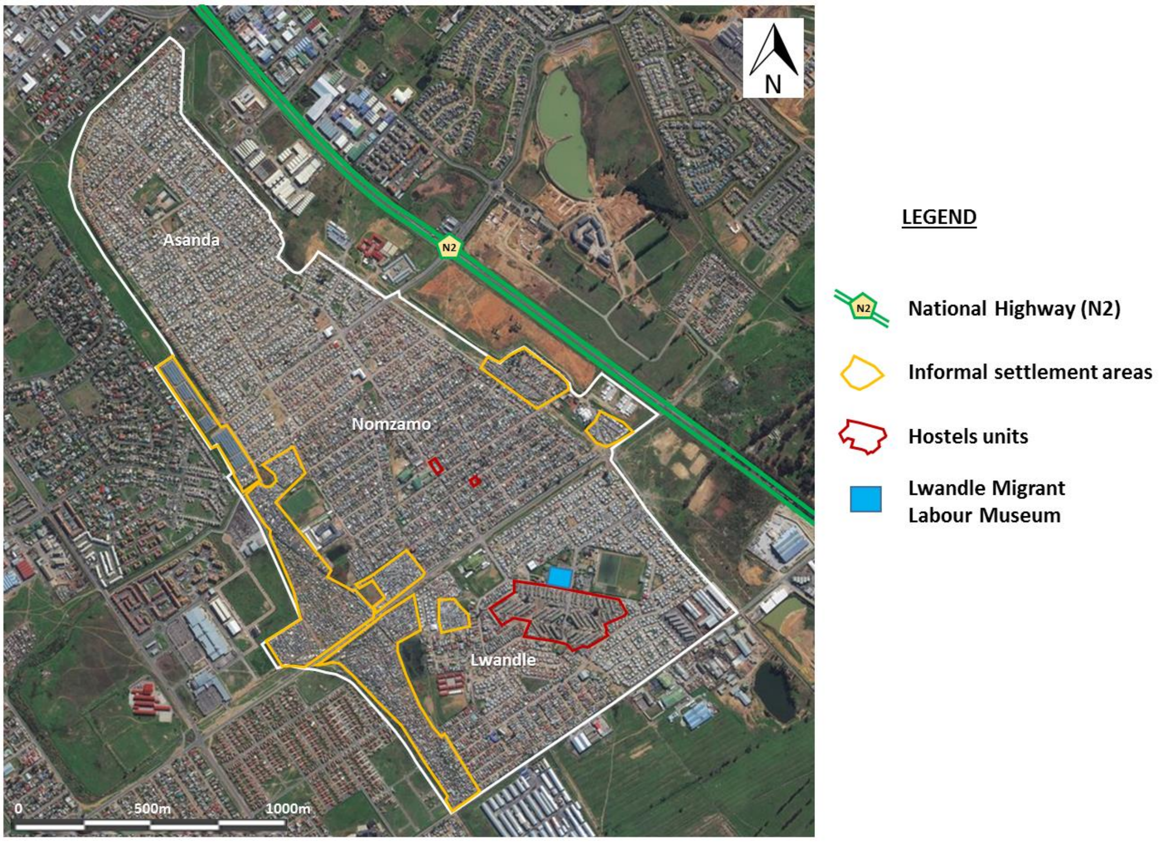


Figure 13 Map of the studysite demarcating different dwelling

Of the 530 households which participated in the household survey, approximately 288 (54.3%) of households surveyed resided in formal dwellings (these included hostel dwellings), 148 (27.9%) within BYDs, and 94 (17.7%) within ISDs. The average number of household members within different dwellings types across the study site was approximately 2.8 people. As can be observed in Figure 14, formal dwellings tend to have larger households of between 3 and 4 members (average 3.34), while most other dwellings tended to have only two or maybe three inhabitants. It was also observed that was a greater proportion of single member households among ISDs and BYDs than other dwelling types.

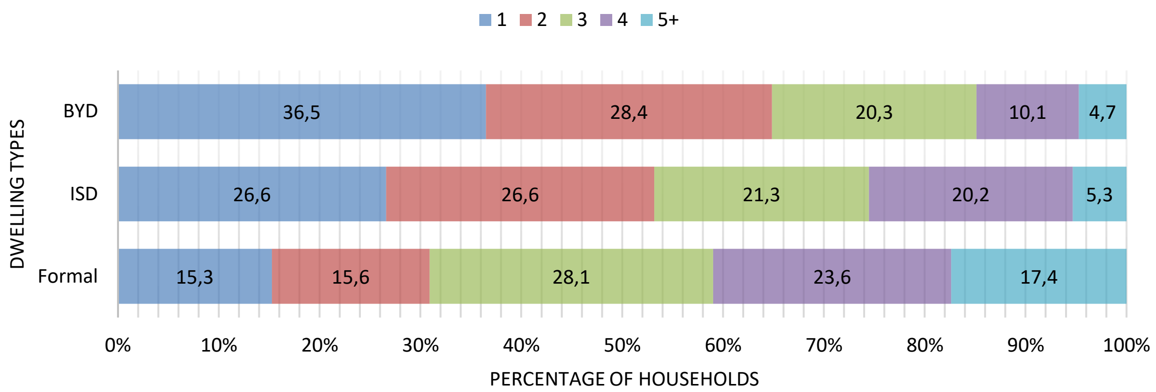


Figure 14 Number of people residing within each dwelling (n=530)

Most households had limited economic resources at their disposal. The 2011 Census data indicate the majority of households across the study site are very poor. On average, 78.6% of the population earned under R3 600 per month (RSA 2012a). While the survey attempted to gain more precise insight into household incomes, 223 (41.6%) of the participating households refused to provide details on their income. Amongst the 307 who did provide a response, on average 72% of households reported earning under R3 500 per month (see Figure 15).

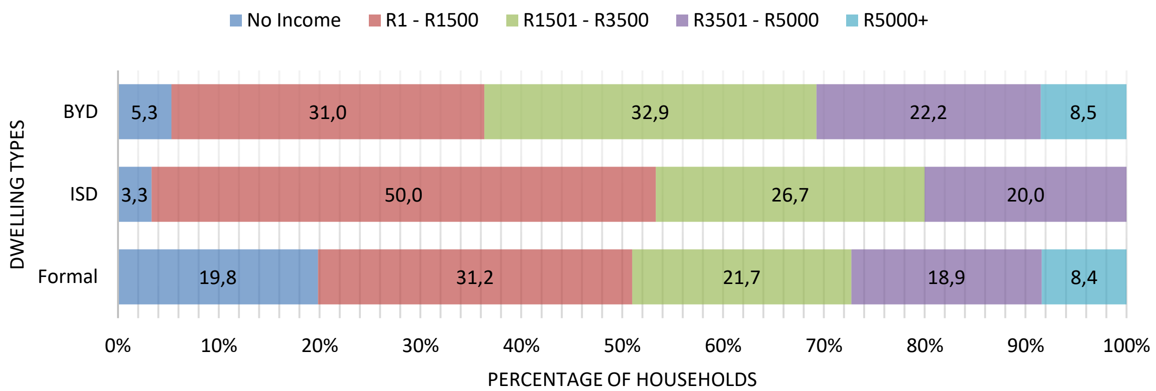


Figure 15 Household income (n=307)

The household survey data showed that approximately 50% of all households had a regular income, usually earned from the employment of a household member. Yet, approximately 118 (22.3%) of households surveyed across the study site had irregular or seasonal incomes (as seen in Figure 16), which may result in periods for households when there is no income being earned. Many households receive social grants such as pensions or child grants which often make up a substantial proportion of their income.

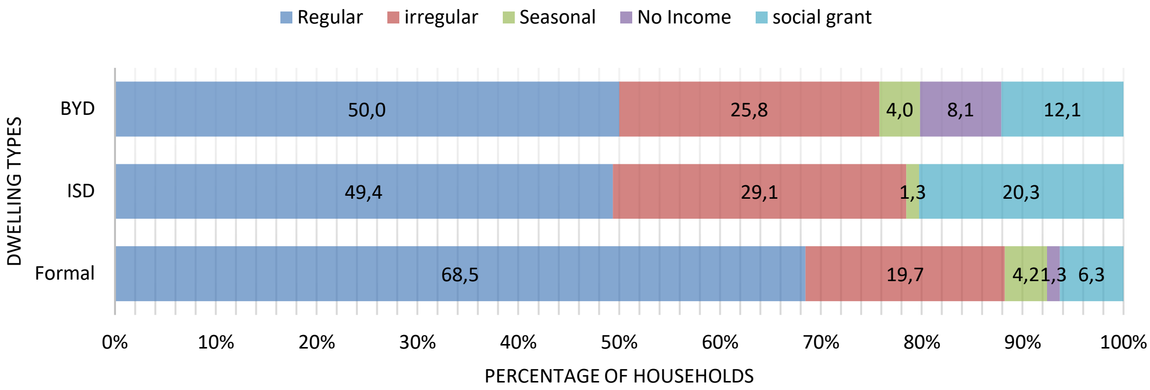


Figure 16 Regularity of household income (n=528)

A major challenge experienced by many households is the high ratio of dependents to breadwinners in each household. According to the 2011 national census, approximately 43% of the study site population are dependents, however this only takes the population between 0 and 15 and over 65 years of age into consideration, not necessarily unemployed adults (RSA 2012a). Discussions with residents in the study area revealed that unemployment is high, with only one or two members of each household supporting several dependents such as children, unemployed adults, handicapped persons and elderly. This issue is particularly the case amongst larger households with only one breadwinner, who often struggle to afford to support the rest of the household members needs such as food, clothing, transport and energy consumption. Approximately 23.6% households in the study site were found to have no breadwinners at all (i.e. no one that was employed at all), and relied solely on social grants such as pensions or child grants, or on informal means to earn a household income.

Table 3 Information regarding household sizes, incomes and number of breadwinners (n=307)

Dwelling type	Average household size	Average income range per household	Average no. of breadwinners per household
Formal	3.34	R 3501 – R 5000	2.32
ISD	2.54	R 1501 – R 3500	0.92
BYD	2.22	R 3501 – R 5000	1.76

4.4 FIRE INCIDENCE IN THE STUDY SITE

The data on fire incidents for the City of Cape Town reveals that the study site has experienced a number of fires between 2005 and 2015 (Western Cape Government 2017). Between 2005 and 2015, as shown in Table 3 and Figure 17, there were approximately 154 fire incidents reported in Lwandle, 165 in Nomzamo and 53 in Asanda Village. Most fires appear to be caused by accidents involving energy sources such as paraffin stoves or candles being knocked over, however, some fires are also linked to electrical faults such as electrical boxes overloading or sparks from informal wire connections igniting flammable materials.

Table 4 Fire incidents reported in Lwandle, Nomzamo and Asanda Village from 2005-2015

	Lwandle	Nomzamo	Asanda Village	total
Formal dwelling fire	27	30	17	74
Informal dwelling fire	127	135	36	298
total	154	165	53	372

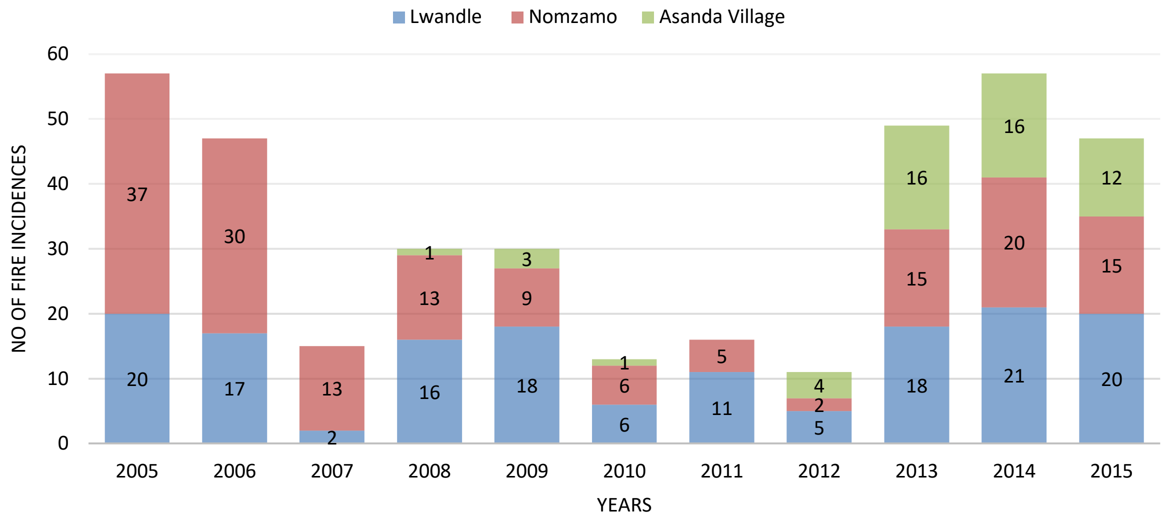


Figure 17 Timeline of reported fire incidents in Lwandle, Nomzamo and Asanda Village from 2005-2015 (n=372)

While damage from fires in the more formalised areas appear to be limited to a single house and or perhaps a few nearby backyard dwellings, fires in predominantly informal areas tend to cause greater damage to numerous dwellings. In 2004, a fire in Nomzamo destroyed 300 (mostly informal) dwellings, leaving over 1500 people homeless and displaced (Ndenze 2004). More recently, in August 2015, over 50 ISDs were destroyed in another blaze, which left over 100 people homeless (Mawu 2015), and another in November 2016 which saw another 150 residents of ISDs in Nomzamo lose their homes to fire (Fisher 2016).

4.5 AVAILABILITY AND USAGE OF ELECTRICITY IN HOUSEHOLDS IN THE STUDY SITE

According to discussions with the Lwandle Migrant Labour Museum manager and older residents (those who have resided there 15 years or longer), until the 1990s, households only had access to non-electrical energy sources such as candles, paraffin, coal and firewood (Soko pers. comm. 2017). Residents gained access to electricity during the 1990s, however this was predominantly via connections which siphoned electricity illegally from nearby electrical infrastructure. Formal electrical infrastructure and services became available to the majority of households during the mid-2000s when the government began to develop formal housing units and upgrade infrastructure in the area. Officially, all formally built dwellings have their own electricity meter box, like the one shown in Figure

18. This meter box was installed during construction, and connects the buildings to the national grid (Traut pers. comm. 2017). During the field work, at least one formal dwelling was found to have no electric infrastructure installed because its construction was never completed.

Figure 18 Examples of an electric meter boxes typically found in formal and hostel dwellings in the study site (author's own photos 2017).

The majority of BYDs, which began to appear during the mid-2000s after formal housing units were completed, could only access electricity informally through their landlords via extension cords running from the main formal dwellings to the BYDs. Some BYDs have individual electricity meter boxes installed, allowing households formal access to the grid that is independent from their landlords. Because of their disputed occupation of SANRAL land, and likelihood of resettlement, the City of Cape Town's electricity department has not provided formal electrical infrastructure or services to the clusters of ISDs to the south of the study site. These households can only access electricity through informal connections.

According to the 2011 census, electricity is widely utilised for activities such as cooking (91.4%), heating (32.7%) and lighting (92.5%) (RSA 2012a). The household survey data closely reflected these findings, showing that 517 (97.6%) of the 530 households surveyed had access to electricity. Approximately 50.4% of all households in the study site acquire electricity through their own electric meter box located within their own dwelling. As shown in Figure 19, the majority of households residing in formal dwellings and hostels have access to formal electrical infrastructure to provide them with electricity.

The other 49.6% of households (almost all informal dwellings) acquire electricity through various methods of informal electrical connection. As shown in Figure 19, the majority of BYDs (86.8%) had informal connections and relied on their landlords or a neighbour (73.6% and 7.8% respectively) for access to electricity. Similar to BYDs, approximately 96.4% of ISDs relied on informal connections.

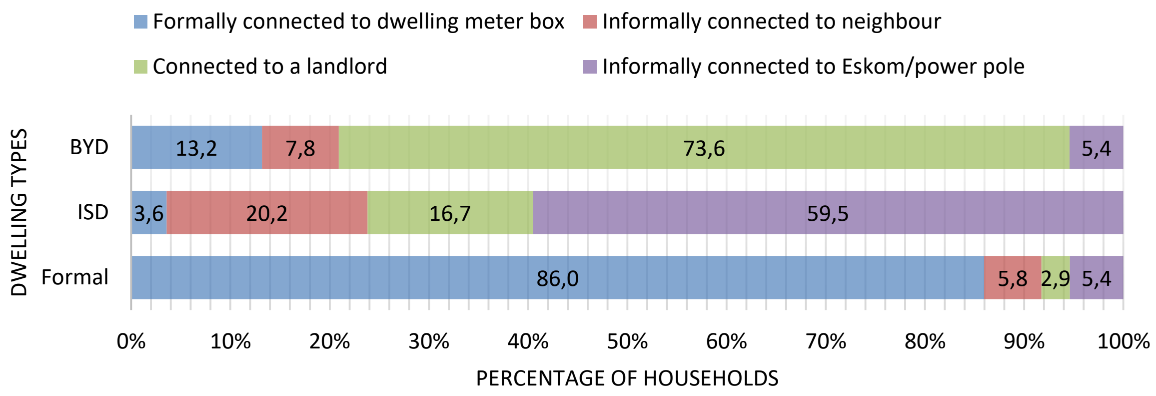


Figure 19 Household access to electricity (n=491)

It was interesting to note that several formal housing and hostel units apparently relied on neighbours or landlords for electrical services. Researchers reported that some hostel units were connected to their neighbouring unit's supply because their electric meter boxes were no longer working.

The majority of informally-provisioned electricity was supplied by formal households (61.7%). According to survey data, 51.3% of formal households surveyed supply electricity to one or more other dwellings, usually a BYD situated on their property. Of these formal households supplying electricity, an estimated 60.8% supplied between 1 and 2 dwellings, and a further 29.2% supplied 3-4. It was found during the focus groups and household survey that some ISD households situated adjacent to formal residential areas acquire electricity from neighbouring formal dwellings. The sharing of electricity between these dwellings is similar to the relationships between formal dwellings and BYDs on their property, with the ISD households paying money to the formal household for access to their electricity. Approximately 36.9% of ISDs were found to access electricity through a neighbour from a neighbouring formal dwelling or a landlord. In many instances, these ISDs then distributed electricity to neighbouring ISDs at a fee. The survey data found that 59.5% of ISDs acquired electricity by siphoning power from formal electrical infrastructure, such as nearby power lines and electricity substations, through an electrical cable. These cables are often placed on informally constructed poles allowing electricity to be shared to large numbers of dwellings (see Figure 20 below).

Figure 20 Informal connections sprawled across informal settlements to provide power to ISDs (author's own photos 2017)

5 FINDINGS ON HOUSEHOLD ENERGY USAGE AND FIRE RISK

5.1 INTRODUCTION

This section presents the findings gathered from discussions with residents of the study site and data collected through the household survey. The first part of this section examines the various types of energy utilised by households for different activities such as lighting, cooking, boiling water and the heating of dwellings. The second section examines the factors that influence household energy choices, such as residents' perceptions of affordability, accessibility and perceived level of danger of different energy sources. The third and final section presents data on dwelling fires caused by different energy sources, reported by residents in the study site, as well as the measures employed by the residents in an effort to mitigate the risk of fires.

5.2 ENERGY USAGE CHOICES IN THE STUDY SITE

5.2.1 Evidence of energy stacking strategies used by households

Overall, the majority of households were observed using electricity for activities such as lighting, cooking and boiling water. Households in the study area perceived electricity as a highly versatile energy source, providing power to a range of appliances such as stoves, kettles, lights, televisions, radios and cell phones. During household interviews and focus group sessions, many residents stated that electricity made their lives easier especially for activities such as cooking, boiling water and heating because all they had to do was switch on an appliance, rather than try to ignite a flammable energy source and keep watch over it to prevent it from setting something alight. During household qualitative interviews and focus group sessions, many households reported using a mixture of electricity and other energy sources such as paraffin, candles, gas, firewood, and/or coal to meet their household's energy needs[2]. According to the survey, 67.2% of households claimed they employed a mixture of energy sources (see Figure 21).

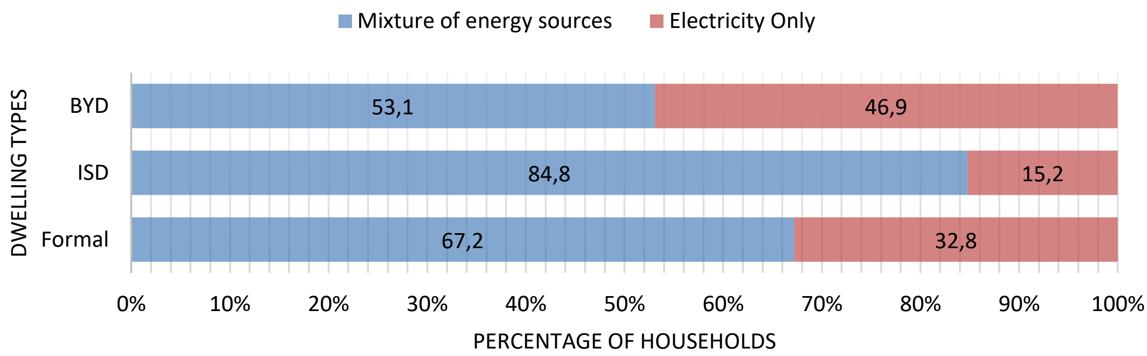


Figure 21 Proportion of households utilising a mixture of electrical and non-electrical energy sources (n=530)

[2] It should be noted that no households reported utilising solar or other sustainable energy sources.

Counterintuitively, BYD based households are more likely to rely just on electricity than formal households, despite being largely reliant on informal electrical connections. This observation along with others will be investigated further in the following subsections, which will examine what energy sources households in different housing types utilised for daily activities.

5.2.2 Energy sources used for lighting: using candles as backup

Through research, it was found that almost all residents use electricity predominantly for providing lighting. According to the household survey data, approximately 84.2% of participating households stated that they used electricity *'all the time'* for lighting (except when there is load shedding or a power cut) with a further 12.3% stating they used it '*most of the time*'. Electricity's popularity as a source for lighting stems largely from residents' perceptions that electricity is easier to utilise (i.e. switch on and off), more effective at lighting to the interior of dwellings and is safer. Even amongst very poor households or dwellings with unreliable and informal connections, households use electricity for lighting as often as possible. Some of these households even stated the only reason they have electricity is to provide better lighting to their dwelling.

For those stating that they only use electricity '*most of the time*', residents in both surveys and interviews explained that they would be forced to rely on other energy sources when electricity was unavailable due to connectivity or affordability reasons. Consequently, a commonly utilised alternative source of energy for lighting is candles. It was revealed during focus group discussions with residents that candles were once the predominant source for lighting, especially among informal households, however, with greater access to electricity through either formal or informal means, residents appear to have significantly reduced their reliance and usage of candles. The household survey found that approximately 31.3% of households stated they would use candles '*occasionally*', while another 24.4% stated they would only use them as backup or an emergency lighting source if they had no choice when electricity is not available to them. It is interesting to note in Figure 22, that there is a large difference between responses concerning usage of candles among BYDs and other dwellings types. For example, formal and ISD dwellings appear to use candles far more frequently than BYDs, while almost half of BYD refuse to use candles compared to only 30.1% and 26.5% of ISD and formal dwellings respectively. This was primarily due to a heightened fear of fire amongst those living in BYDs. Those living in BYDs stated that they prefer to use electricity over flammable and potentially dangerous sources of energy in their small and cramped dwellings, where items can easily catch fire and fires spread rapidly.

Paraffin is the least utilised energy for lighting, with approximately 60.3% of all households stating that they would never utilise it. The frequency of paraffin usage does vary somewhat among different dwelling types. As seen in Figure 22, while 50.5% of ISDs stated that they never utilise paraffin for lighting, approximately 31.2% use it '*most of the time*' or '*occasionally*'. Statistics for formal dwellings mirror these findings with 32.3% of households using paraffin '*most of the time*' or '*occasionally*'. These figures significantly contrasts the 82.4% of BYD households which stated they would never utilise it. Similar to perceptions concerning candles, it appears BYD residents prefer to not utilise flame-based energy sources to avoid the risk of a dwelling fire breaking out. It was observed that households that tend to use paraffin more frequently do so because they also utilise it for other activities such as cooking food, heating the dwelling and boiling water. These findings will be explored further in the following sections 5.3.3, 5.3.4 and 5.3.5 concerning cooking, heating and boiling water. Other energy sources such as gas, firewood and coal are used by very few households across the study site and then only on rare occasions. One household described that during a braai or a traditional ceremony when a fire was lit, often the fire provided sufficient light for the surrounds so there was no need to waste electricity or candles for unnecessary lighting.

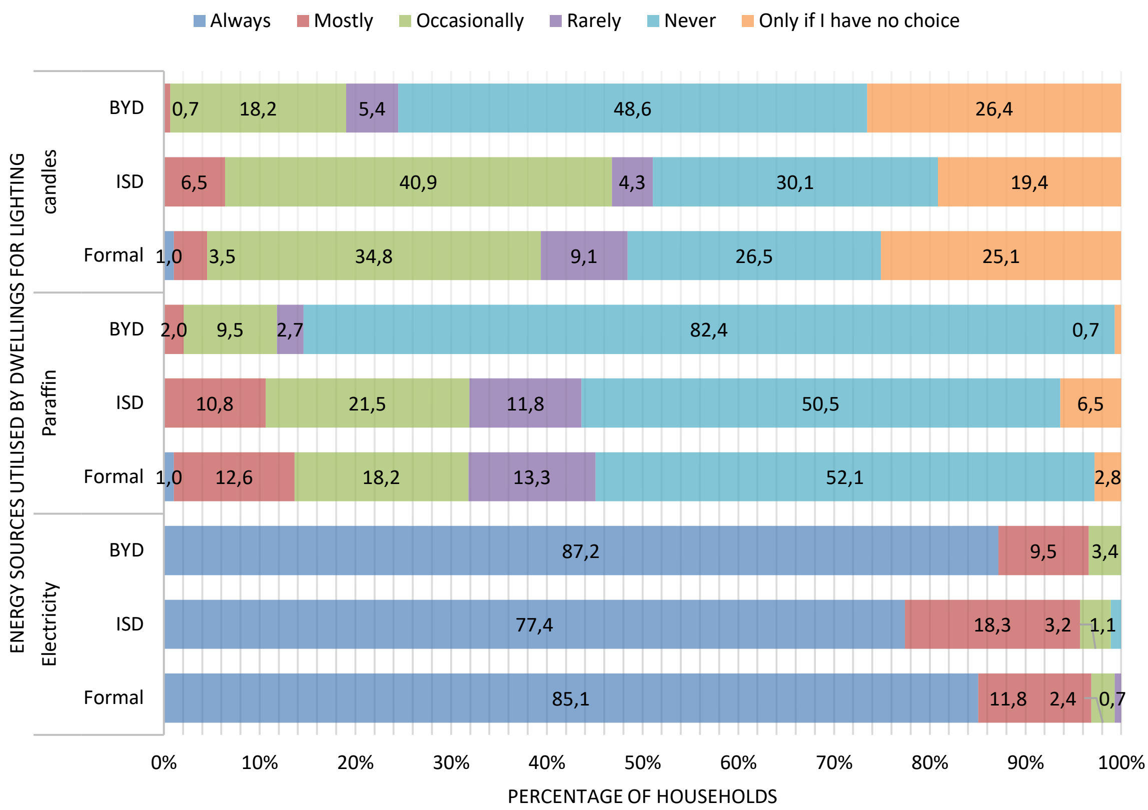


Figure 22 Energy Sources used for lighting by households (n=530)

5.2.3 Energy sources used for cooking: A recipe of multiple fuels to feed the family

Electricity is used by most households for cooking meals. According to the survey data, 64% of all households stated that they use electricity every time they cook and a further 26% use electricity '*most of the time*'. ISDs are generally less likely to use electricity for cooking; as shown in Figure 23, only 40.4% of households use electricity for cooking *'all the time'*, 38.3% *'most of the time'* and 10.6% stating they never use electricity for cooking – this most likely stems from weaker and less reliable access to electricity often experienced in informal settlements. Interestingly, however, households in BYDs are more likely to use electricity for all cooking (79.1%), compared to formal dwellings (62.9%). It would appear from discussions with BYD dwellers that many such households are cautious about using flame-based energy sources within their largely wooden and confined dwelling, which could result in a fire and the destruction of their home. On the other hand, it appeared that formal dwelling residents felt more secure in their dwellings which they felt are at less risk of being burnt down in case of an accident, thereby allowing them to feel more confident in using non-electric energy sources.

Paraffin is not as frequently utilised as electricity, however many people use it as an alternative fuel source for cooking when electricity is unavailable. Approximately 48.2% of households across the study site owned a paraffin stove, which they utilised for cooking. Only 24.1% of households stated that they would '*occasionally'* utilise paraffin for cooking in comparison to the 44.1% of those who would '*never'* utilise it. An interesting finding during focus group sessions is that paraffin is often used on a seasonal basis rather than weekly or monthly. Many residents stated that during the winter or particularly cold spells, most households across dwelling types cook more frequently with paraffin as it doubles as a source of heating. When discussing the findings of the survey with several residents of the study site, one stated "if you had asked these questions in July and August, all those reds and greens (referring to the Figure 23's bars for '*most of the time*' and 'o*ccasionally*') will turn blue (referring to '*all the time'*)". This phenomenon shall be explored in the following section concerning heating.

All households were generally least likely to use gas out of the three energy sources, although, as seen in Figure 23, 34% of households living in ISDs utilise gas 'm*ost of the time'* and '*occasionally'* 17% each. Similar to paraffin, a significant proportion of households (over 60% across all dwelling types, except ISDs at 45.7%) stated that they would '*never'* utilise gas for cooking. Very few households stated that they would resort to gas if they had no choice or an emergency. Larger households tended to utilise gas, stating that it was very efficient for cooking for large families. One interview with a woman who ran a crèche from her home, stated that cooking meals on gas for up to 15 children at a time was much more efficient and cheaper than if she had to cook using electricity and electric appliances.

According to the household survey, relatively few households utilise firewood and or coal for cooking. Discussions with residents during focus group sessions revealed that firewood and coal are used more for social events that occur a few times a year, such as family gatherings, 'Sunday braais', holidays and traditional ceremonial events in which one needs to feed many people. The most common appliance used is an 'mbawula' (a makeshift fireplace often constructed from a steel drum). The minority of formal and informal dwellings that cook with these sources frequently operate businesses where they sell cooked meat. Several residents state that they prefer cooking and eating food cooked using firewood and/or coal as it reminded them of their homes and families in more rural areas of South

Africa, where cooking with wood and/or coal is more common. Many stated that if it was not for the lack of collectable natural wood and coal, lack of adequate fire facilities such as fire places and chimneys, as well as the issue of smoke pollution in highly densified settlements, they would probably use such sources to cook more frequently.

During focus group sessions and household interviews, it was found across households, regardless of housing type and sometimes level of income, that if money was running low in the household, residents would rather not use energy sources to cook. Households tend to prefer to save the remaining energy to power electronics such as televisions or lights, or rather saving the money they would have spent on energy for other activities or on food. During these times when they could not use energy to cook, residents said they would resort to eating plain bread or other foods that are cheap and needed no cooking to make.

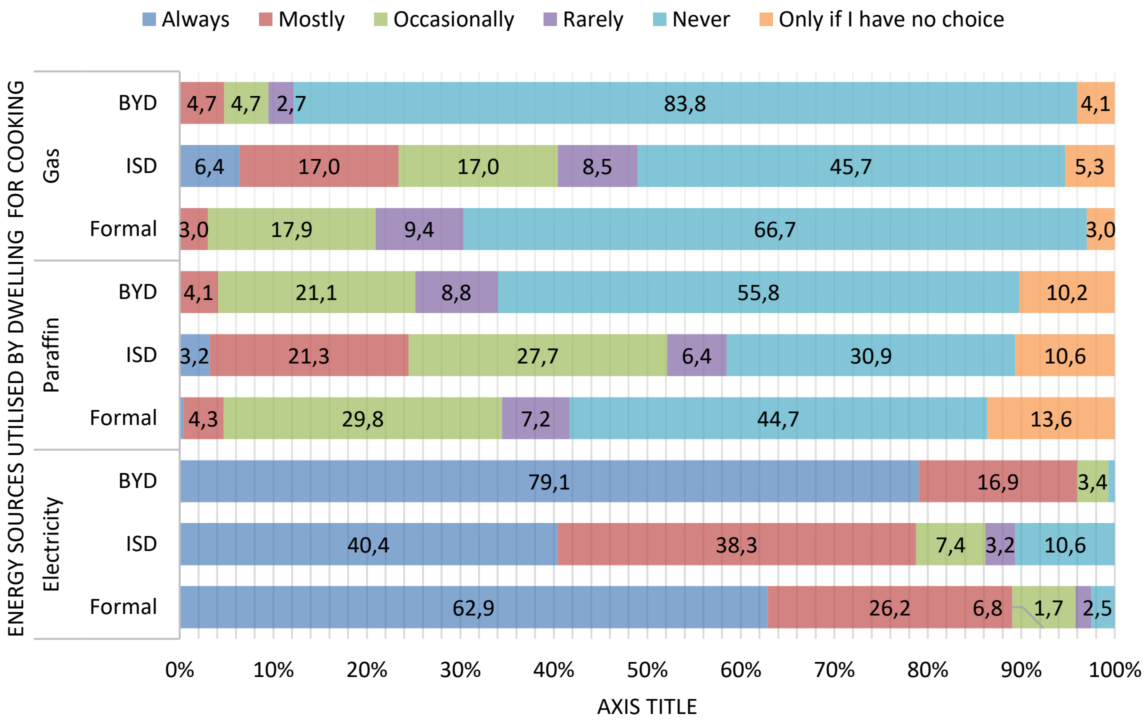


Figure 23 Energy sources used for cooking by households (n=491)

5.2.4 Energy used for boiling water: an electric kettle in every home

For many low-income households, the ability to access hot water is a daily struggle. Many households, particularly ISDs, BYDs and hostel units share communal taps, with very few of them providing hot water. Consequently, a great number of households have to boil their own water for cooking, washing and bathing. According to estimates from the survey, approximately 67.5% of all households utilise electrical appliances such as kettles or stoves to boil water '*all the time*', with a further 25.3% stating they used electricity '*most of the time*' for boiling water. Electric kettles are very popular and are found in almost all dwellings across the study site.

Paraffin appears to be a major alternative to electricity for most households, however, the frequency of its use is varied according to different dwelling types. As seen in Figure 24, ISDs tend to use paraffin as a secondary source more frequently than other dwellings, of which 20.2% state they utilise it '*most of the time*' and a further 28.7% using it "*occasionally*". Amongst households residing in formal dwellings and BYDs, the majority of residents stated that they rarely or never use paraffin. Discussions with residents during focus group sessions revealed that paraffin was often used when electricity was running low or had run out, or to save on electricity, as boiling pots of water consumes large amounts of units. Gas is a somewhat popular alternative for boiling water, particularly among informal households, however like paraffin it was less frequently utilised by BYDs and formal dwellings, compared to ISDs. Discussions with residents found that many people thought gas was more efficient than electricity for boiling large amounts of water for activities such as bathing and washing, while electric kettles are better for boiling water small amounts of water for things like cooking or making tea/coffee.

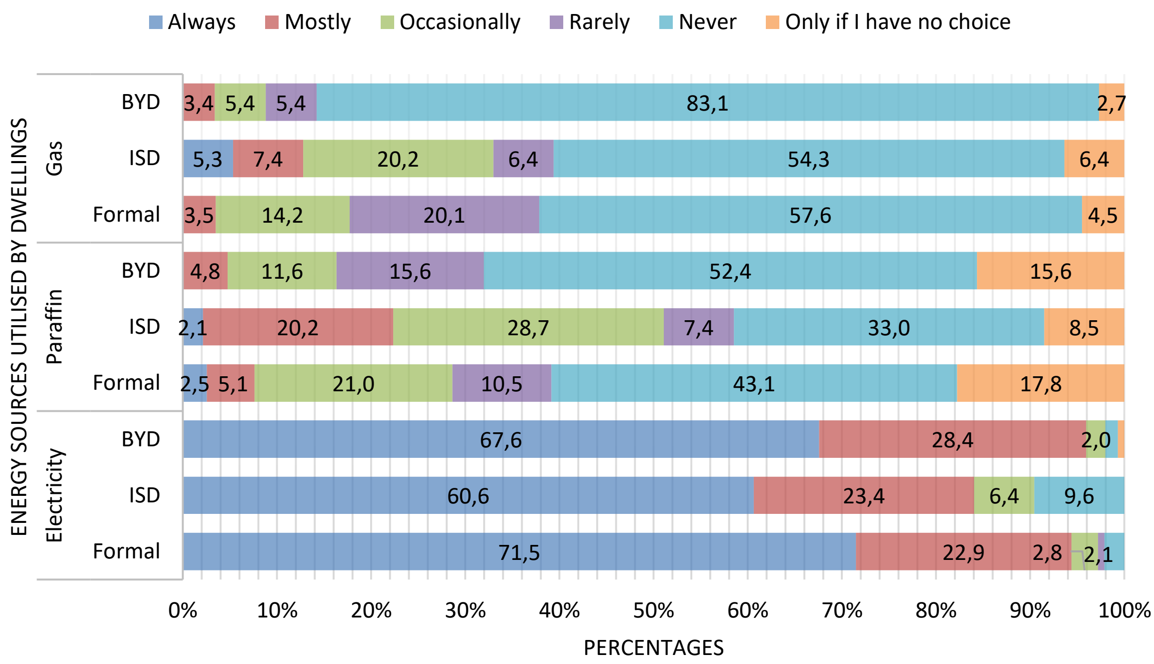


Figure 24: Energy Sources used for boiling water by households (N=509)

The majority of households indicated that they do not utilise energy sources such as firewood or coal. Many residents stated that while fire was good for cooking food, it took longer to heat up water via an open fire. It was also considered difficult and less safe to boil large quantities of water over a fire. One of the residents in an ISD household runs a business selling flame-grilled meat utilises the same flames to boil water in kettles and pots for her own household needs, as well as selling it to neighbours for them to use for washing and bathing.

Solar geysers were originally installed in hostel units to heat water. It was thus surprising that only 5.9% of hostel units utilised solar geysers most of the time and a further 5.9% used them 'rarely'. However, during field research and community engagement sessions it was learned that most solar water geysers, particularly in the hostel units in Central Lwandle, had been stolen by gangs to be sold on the black market or for scrap (as shown in figure 25). Unfortunately, despite complaints from the community, there appears to be no action taken by government to replace these geysers.

Figure 25 Solar Water Geysers stolen of roofs of Lwandle hostel dwellings

5.2.5 Energy used for spatial heating: a conflict between keeping warm or saving energy

Discussion with residents during focus group sessions and household interviews sessions revealed that Lwandle, Nomzamo and Asanda can get very cold, especially in winter. Many BYD and ISD dwellers complained that their dwellings are poorly insulated and would feel "just as cold inside as outside". Consequently, it is common for households to utilise energy sources to provide spatial heating within their dwellings.

According to the survey responses, households are most likely to use electricity to heat their dwellings, with 28.2% of households using electricity '*All the time*' and 16.1% stating they would use it '*Most of the time'*. Responses concerning frequency of electricity usage vary across different dwelling types, with formal dwellings and hostel units utilising electricity more frequently than ISDs and BYDs, as can be seen in Figure 25. As a result, devices such as electric blankets and electric heaters are often utilised more so in formal households than other dwelling types.

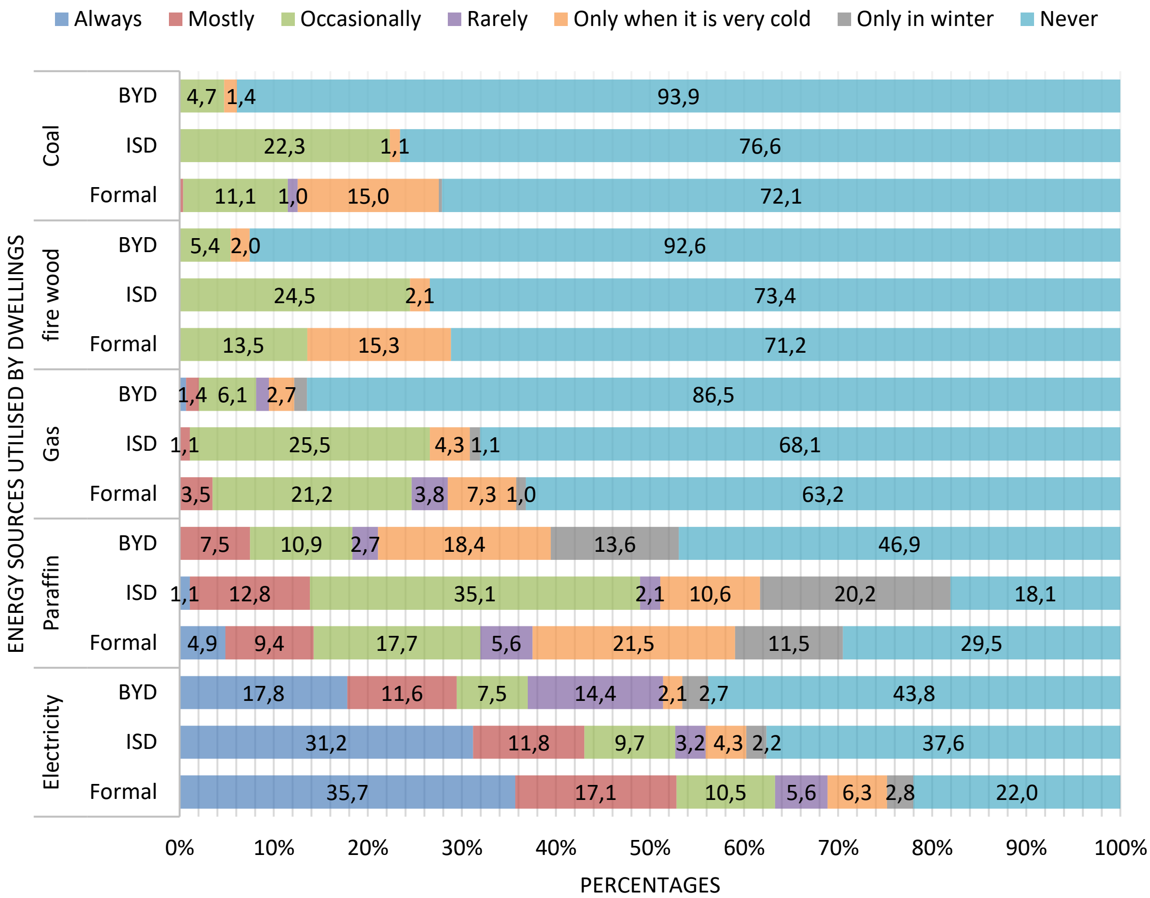


Figure 26 Energy sources used for heating by households (n=486)

While electricity is still widely utilised in households for heating, the proportion of households using electricity '*all the time'* was significantly lower than for other activities. In the qualitative research, people explained that appliances such as electric heaters consume a lot of electricity, depleting their electric units faster and costing them more. Therefore, most households stated that they use electricity less often and rely on a diversity of energy sources to assist in alleviating the cold.

Paraffin is the most commonly utilised alternative energy source for heating. A significant proportion of households, particularly those in formal and informal dwellings, state that they already utilise paraffin frequently ('*most of the time'* 18.6% and *'occasionally'* 35.1% respectively). These responses aligned to earlier observations made concerning energy usage and cooking, in which paraffin would be used for cooking and providing warmth simultaneously.

Gas, firewood and coal are used less often for heating. With the exception of households living in hostels, where 10% used gas '*only when it is very cold'*, gas is used less than paraffin for heating. Similarly, firewood and coal are used by a minority of households probably because very few dwellings in the study site, particularly among ISDs, BYDs and hostel units, have adequate fire places or chimneys within their dwelling. Approximately 17.5% of formal households stated that they would utilise wood and or coal. Many of these have a built-in fireplace in their dwelling allowing them to safely burn the wood and or coal. Several residents did reveal during focus group discussions that a strategy of keeping warm among some households, particularly residents of ISDs, was to bring in hot coals or burning logs from a fire into the dwelling and place them in 'mbawulas' to provide heat. Mbawulas are very rarely used, according to residents, as it was perceived to pose a significant fire hazard, particularly to informally built dwellings such as BYDs and ISDs.

While many households use one or more energy sources to heat their dwellings, during qualitative household interviews, residents reported that they often struggle to afford the extra energy needed to warm up their dwellings. It was estimated that approximately a quarter of households across dwelling types do not employ any energy sources to heat their homes, and keep themselves warm by wrapping themselves up in blankets and wearing extra clothing.

5.3 FACTORS INFLUENCING HOUSEHOLD ENERGY CHOICES

Though electricity is the most preferred energy source for the majority of households, the research suggests that their use of electricity may be constrained by their ability to afford electricity or whether their electrical connections are able to support their energy requirements. As a consequence, many households are forced to utilise less desired and more dangerous energy sources because they are more affordable and accessible to them. This section examines the factors influencing households' energy choices.

5.3.1 Factors influencing the utilisation of electricity

5.3.1.1 Variable views on the affordability of electricity

Households' opinions on the affordability of electricity varied across dwelling types. Approximately 46.9% of all surveyed households believed that electricity was either '*affordable'* or '*very affordable*' against 36.8% who felt it was '*expensive' or 'very expensive'*. As seen in Figure 26, households living in ISDs are more likely to view electricity as expensive – 43.5% believe that electricity is '*expensive'* or '*very expensive*', versus only 29.8% who consider it '*affordable'* or '*very affordable'*. Residents of ISDs also complained that the rates they pay for access to informal electricity networks are too high and unfair as many households who distribute it acquire it for free through illegal connections.

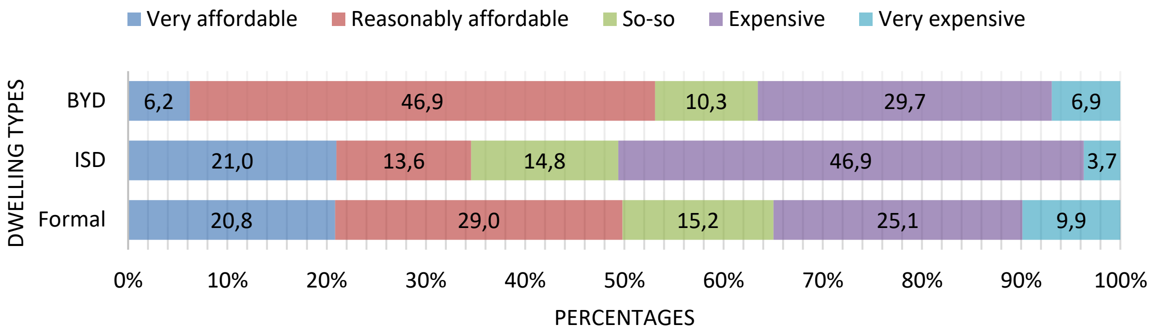


Figure 27 Household perceptions on affordability of electricity (n=524)

Current average household spending on electricity was estimated at approximately R302.97 per month across dwelling types. Most households spend between R150 and R350 per month (59.5% formal; 56.8% ISD; and 65.5 BYD). Of ISD households who do pay for electricity, about 50% of households spent under R250 per month with another 42.8% spending between R250 and R500 per month. A major issue for many households was their inability to purchase adequate amounts of electricity to meet their energy needs. Some households could only afford enough electricity to provide power to lighting, television sets, and only occasionally for cooking, for which they generally used other sources of energy.

Many residents, especially from formal dwellings, complained that in the past few years electricity had become increasingly expensive due to the rising price of electricity. However, it was difficult to ascertain quantitatively how much more residents were spending currently on electricity compared to previous years, as very few kept record of their energy expenditure. It was interesting to observe, that while some residents stated that price hikes had forced them to curb their expenditure and usage of electricity, other residents stated that the price hikes had done little to influence their energy choices. Such residents (usually those earning higher incomes) generally stated that they are prepared to bear the burden of increased electric costs to keep utilising it over non-electric energy sources because issues such as safety and convenience.

The qualitative research findings suggested that households earning higher incomes tend to utilise electricity as their primary and sometimes sole energy source. As shown in Figure 27, the household survey supported these observations, with the proportion of households using only electricity rising in higher income earning groups. The probable reason for this is that households with higher incomes can better afford both electricity and the electrical appliances and their associated costs, and therefore do not need to resort to other energy sources. Conversely, lower income earning households tended to utilise a greater variety of energy sources more frequently.

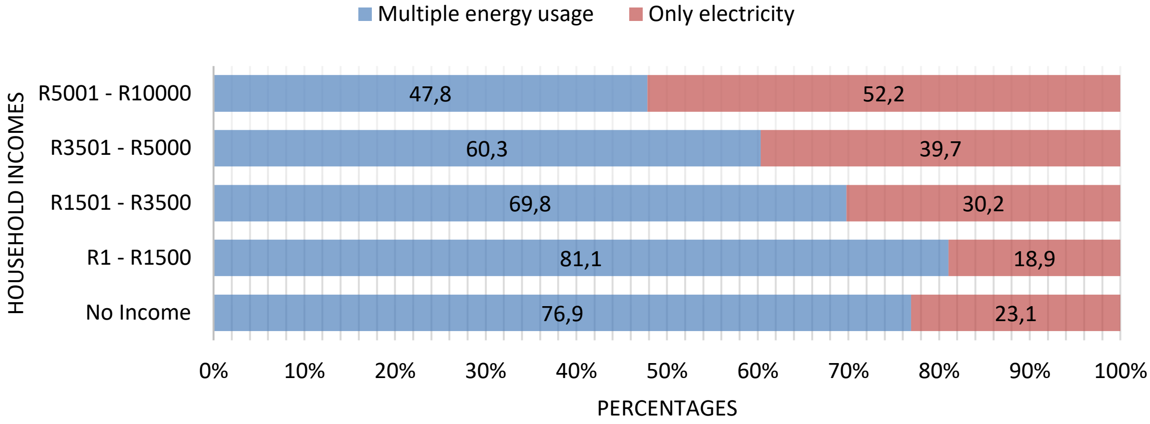


Figure 28 Household income levels and energy usage (n=307)

Perceptions on the affordability of electricity was also influenced by household size. During qualitative discussions with residents, smaller households with one or two members generally found electricity to be affordable and are able to buy adequate amounts of electricity, because their consumption was low. As Figure 28 shows, these findings are reflected in the survey data, with larger households viewing electricity as *'expensive'* or *'very expensive'*. This was particularly experienced by large households that had a single breadwinner earning an income to support several dependents in the household. Despite finding electricity expensive, some households continued to utilise electricity because they preferred to use it over alternative energy sources because of safety concerns.

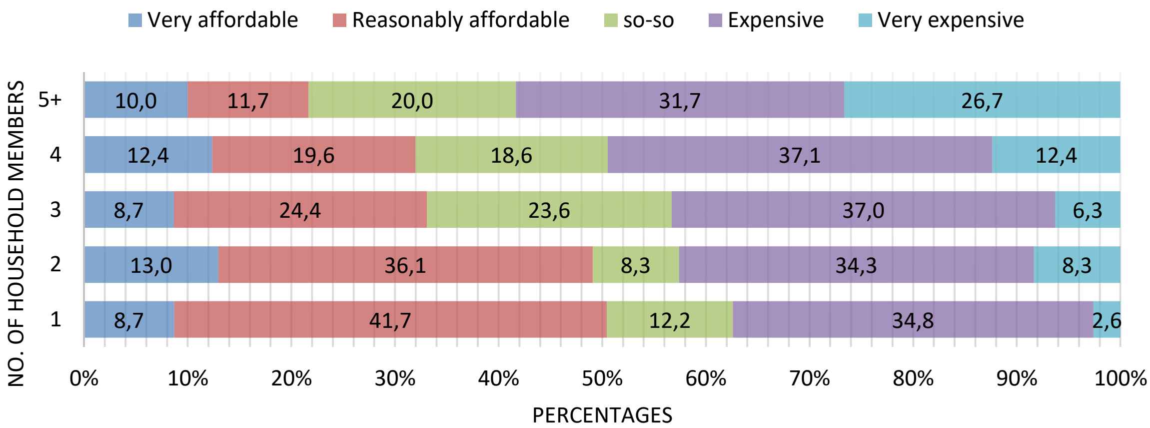


Figure 29 Household perceptions on affordability of electricity according to number of members residing in dwelling (n=524)

5.3.1.2 Accessibility of electricity influenced by quality of connection

Another factor influencing the usage of electricity in households is their ability to access electricity and the quality of the connection. As Figure 29 shows, approximately half of households in all three housing types found it easy to access electricity.

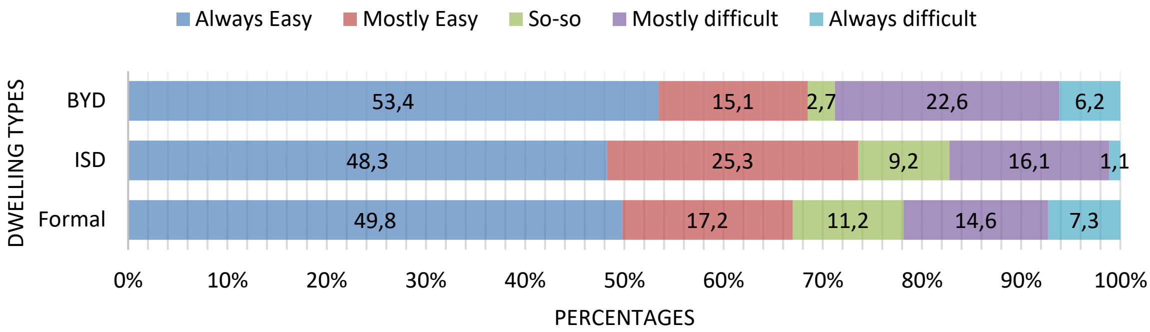


Figure 30 Household perceptions on accessibility of electricity (n=522)

During the qualitative research, residents stated that they can easily purchase electricity vouchers (to insert codes into their electric meters to grant them electricity) from local spaza shops, which are often open until late evening – although one elderly couple who lived by themselves complained that due to their age and poor health, they are unable to walk the distance to the spaza and rely on the availability and generosity of their neighbours to purchase it on their behalf. People are also purchasing electricity using online banking applications (apps) via their smartphones, reducing time and travel to purchase physically from shops.

Despite most households having physical access to electricity, informal connections are generally poor quality and considered less reliable and safe. BYDs are usually one of several households utilising a landlord's electricity, and do so at the whim of the landlord, and can be cut-off if they have a falling out with the landlord. They are also prevented from using too many appliances, as overloading can result in power cuts and damage to connections and appliances. ISDs face similar problems due to sharing power with multiple households. Consequently, ISDs and BYDs are limited in accessing electricity due to poor quality and consistency of connections, and thereby must use an energy stacking approach.

5.3.1.3 Electricity perceived as the safer energy option

Discussions with residents across the study site revealed that one of the key reasons for households' preference for electricity is because it is perceived as the safest source of energy. The majority of residents stated they felt much safer using electricity and electric-based appliances for activities such as lighting, cooking, boiling water and heating homes, than if they used non-electric, flame-based energy sources (this will be explored further in section 5.3.2). Such sentiments are echoed in Figure 30, in which the majority of households stated that they felt the danger of fire posed by electricity as '*Very Low*' or '*Low*'. Most households believe electricity significantly, if not completely, reduced the risk of fires.

However, despite the positive safety attributes credited to electricity and electrical appliances, many of these households still recognised that electricity could be dangerous. Those living in ISDs and BYDs spoke of the danger of overloading electricity boxes and/or plugs by utilising too many electric appliances simultaneously, and also acknowledged that faulty connections and plugs, and exposed wiring could cause fires. Several households reported fires occurring under their beds because the plugs beneath it got overheated and caused the mattress to ignite.

The perceptions of households living in BYDs was comparable to those in formal housing, however, some formal households felt that the presence of BYDs increased the risk of fires. Many households rented out BYDs on their property. Because BYDs are often situated close to the formal dwelling, a fire could jump from the BYD to the formal house. Some of these BYD-based residents stated that if there are too many electrical appliances working simultaneously, this could also result in plugs or connections in the formal dwelling overheating and or producing sparks in the main dwelling. One resident stated they believe that electricity can produce a false sense of security, leading to unsafe usage of electrical appliances, such as leaving electrical appliances such as irons or electric stoves to overheat which could set items nearby alight.

The majority of ISD-based households believed electricity to be a safe and relatively less dangerous energy source. Many ISD dwellers stated they preferred to use electricity and electric-based appliances because they felt it was less likely to cause a fire in their homes, and assisted in reducing their usage of more dangerous non-electric energy sources such as candles and paraffin. Unlike formal and BYDs, a greater proportion of ISD households saw electricity as potentially dangerous. As seen in Figure 30, approximately a third of such households perceived the danger posed by electricity to be '*high'* (32.3%) to '*very high'* (3.2%). Such ISD dwellers recognise that sparks from informal wiring and faulty appliances are a potential cause of fire, especially if they are not properly maintained or handled safely.

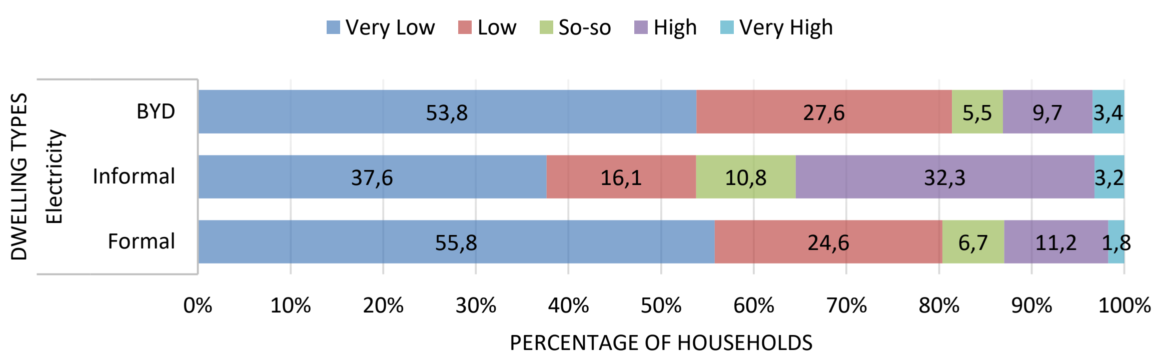


Figure 31 Households rating how dangerous they believe electricity is (n=523)

5.3.2 Factors influencing the utilisation of other energy sources

Due to the issues of affordability and accessibility of electricity mentioned in the previous section, many households are forced to frequently utilise other energy sources. These sources are often more affordable and accessible than electricity, making them an attractive alternative, however, many residents may feel hesitant employing such sources as they are perceived as potential hazards that may increase the risk of a dwelling fire.

5.3.2.1 Paraffin: easy to buy and share, but considered highly dangerous

After electricity, paraffin is one of the most utilised energy sources in the study site, because it considered highly versatile as it can used for multiple activities such as cooking, boiling water and heating, as well as being readily affordable and accessible. In the focus group discussions and interviews, residents noted that affordability and accessibility to paraffin varies seasonally. During the summer months, when paraffin usage is lower, it is cheaper, making it both more affordable and accessible. It becomes less affordable and accessible in winter, when demand rises, making it more expensive. There are also often paraffin shortages at local spaza shops. Consequently, residents have to either reduce their usage of paraffin to make it last longer, or travel further to the nearby shopping centres of Somerset west and Strand to find paraffin, which costs further time and money for the transport.

Despite these challenges, paraffin remains relatively affordable. According to the survey, most households consider paraffin to be between '*reasonably affordable*' (41.3%) and '*very affordable'* (19.3%). It was found that 41.4% of households spent under R50 on paraffin per month, with a further 28.2% spending between R51 and R100 per month. On average, household expenditure on paraffin was R91.33 with the most commonly purchased amount being R50.

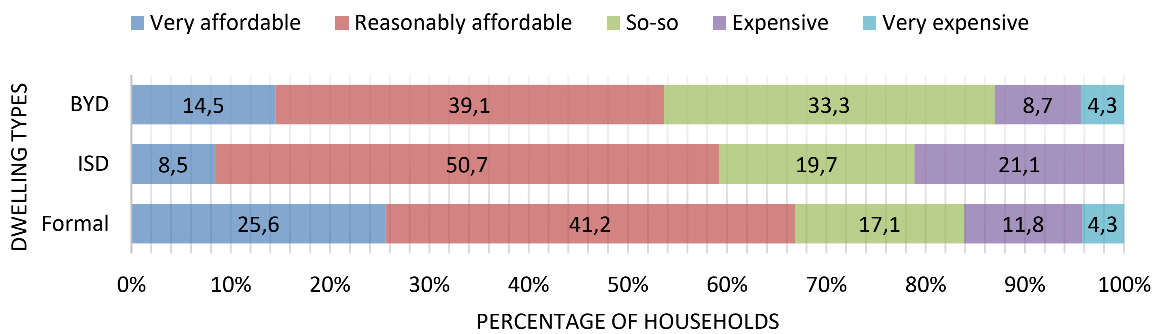


Figure 32 Household perceptions on affordability of paraffin (n=363)

Paraffin is also considered to be easily accessible. It is sold in almost all spaza shops, and is easy to transport and store. It is also easy to share among households who often borrow (or purchase) from their neighbours if households run short. As can be seen in Figure 32, residents of ISDs tended to believe that paraffin was less accessible than other households believed. The qualitative research suggests that this was because they often live further from spaza shops, making travelling back and forth to buy small quantities at a time challenging and tedious.

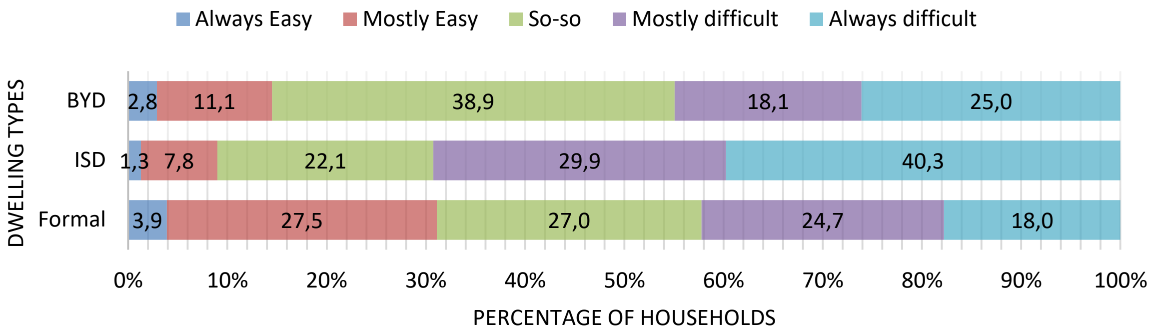


Figure 33 Household perceptions on accessibility of paraffin (n=367)

Discussions with residents during focus groups, door-to-door interviews, as well the data collected from the household survey revealed that the majority of residents perceive non-electric energy sources as highly unsafe and they are commonly blamed for fires. Approximately 38%-43% of households perceived the dangerousness of paraffin as a '*high*'/'*very high*', while less than a quarter considered it to be safe. It was interesting to note the difference in perception of the danger paraffin posed by different households as seen in Figure 33, in which the majority of formal households perceive the danger of paraffin as very low, while a higher proportion of BYDs and ISDs believe it to be more dangerous. Paraffin and paraffin-based appliances are perceived by many households to be particularly dangerous, as paraffin stoves can be easily knocked over, causing the flammable fuel to spill and spread across surfaces. Many households have described paraffin stoves and heaters 'choking' in which paraffin stoves spout out bursts of flame as if the stove was coughing out flames or causing mini 'explosions', particularly if the paraffin has been contaminated with water or petrol, or if there are strong gusts of wind, which may set nearby objects alight.

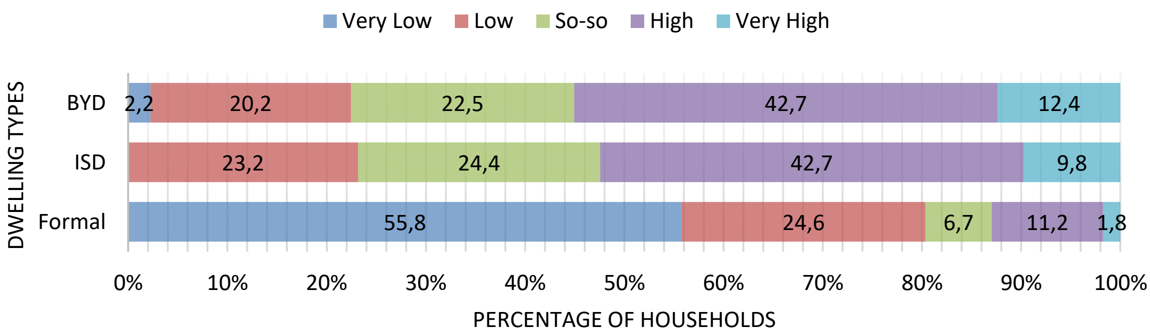


Figure 34 Household perceptions on level of danger of paraffin (n= 497)

Another important factor to highlight from discussions with residents are the perceived health impacts of paraffin. The majority of households stated feeling unwell when using paraffin, particularly when cooking, as breathing in its fumes caused them to experience difficulty breathing, light-headedness, drowsiness and disorientation. Several residents commented that they feel these symptoms further increase the risk of fire in the dwelling. For example, someone experiencing disorientation due to inhaling paraffin emissions could accidentally knock over the paraffin appliance or knock something flammable into the fame, hence causing a fire. While such negative effects were reported by residents across the study site and across housing types, it appeared that those residing in ISDs experienced such symptoms more frequently and more severely than other households due to their greater usage and dependence on paraffin as well as because of poor ventilation in their dwellings which allows paraffin fumes to concentrate rather than disperse, increasing the risk of inhaling its toxic emissions.

5.3.2.2 Candles: affordable, accessible but infamous as a fire hazard

While residents universally agree that electric lightbulbs are far superior to candles in effectiveness in lighting rooms, safety and longevity, they admitted that candles are still a useful alternative because they are easily accessible and affordable at local spaza shops, and if looked after correctly, are reusable too (i.e. the melted wax can be turned into a new candles). The qualitative research suggests that households often keep candles for emergency usage, in case they unexpectedly run out of money to buy more electricity. Other households stated that they are utilised as a means to help save money, or electricity, for other necessities. As can be observed in Figure 34, candles are considered '*very affordable*' by majority of households with only 13 households out of 530 believing them to be expensive.

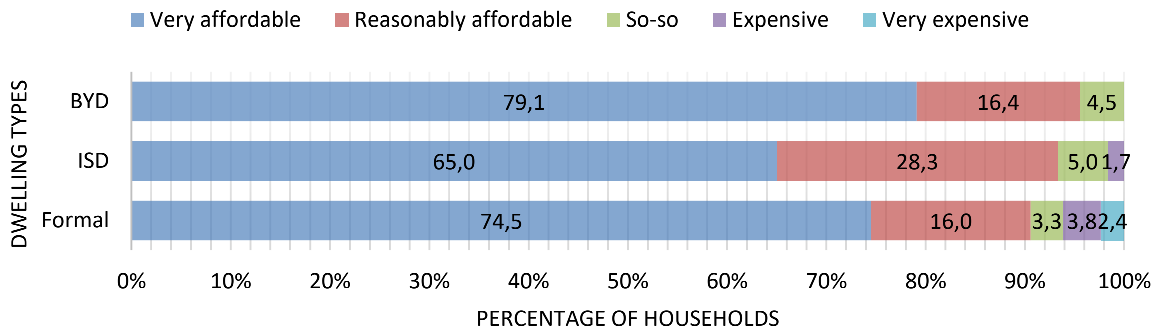


Figure 35 Household perceptions on affordability of candles (n=350)

However, despite their advantages from accessibility and affordability, candles are widely considered unsafe and perceived as the main culprit for dwelling fires. More than half of all households rated candles as having a '*high'* or '*very high'* danger rating. These findings are in keeping with the focus group discussions, where residents repeatedly mentioned the dangers of candles being knocked over or left unattended as a common cause for fires. As seen in Figure 35, the majority of ISD and BYD households perceived candles to be more dangerous than those residing in formal dwellings.

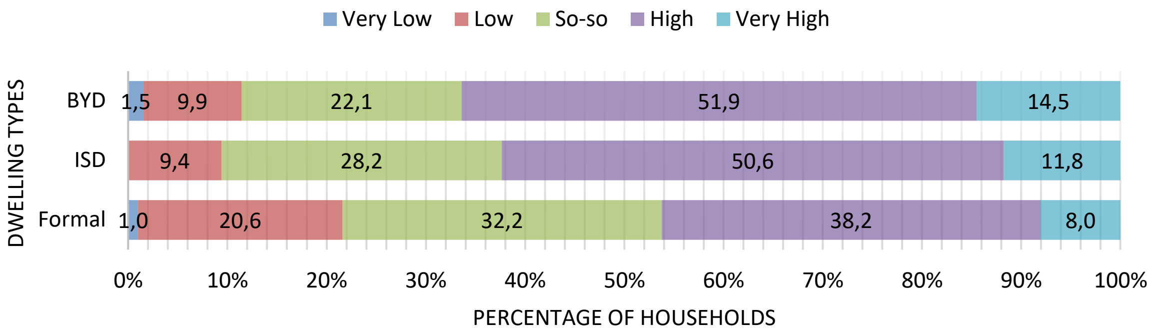


Figure 36 Household perceptions on level of danger of candles (n= 458)

5.3.2.3 Gas: perceived as highly efficient, but the threat of 'explosions' reduces its popularity

Perceptions of the affordability and accessibility of gas varied across households. As can be observed in Figure 36, a greater proportion of ISDs and formal households perceive gas to be expensive while more BYD households thought it to be affordable. The average expenditure of households across the settlement on gas was estimated to be about R150 per month.

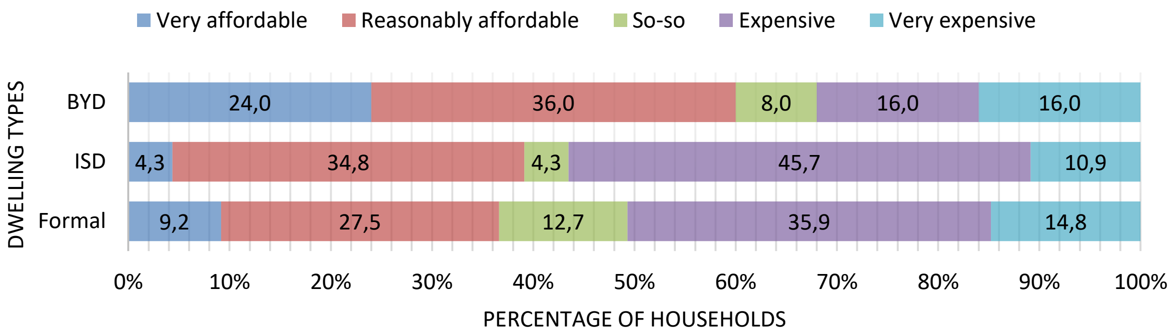


Figure 37 Household perceptions on affordability of gas (n=241)

It was observed that BYDs tend to buy less gas, with 53.6% of households purchasing up to R100 of gas a month. It was interesting to note that gas is considered to be more affordable by larger households than electricity, paraffin or other energy sources. In both household interviews and household surveys, many residents of larger households that gas is employed frequently for cooking as it is easier and cheaper to cook for more people using gas stoves than electric or even paraffin ones.

Generally, households consider gas to be difficult to access, as can be seen in Figure 37. Residents stated that gas is seldom sold at local spazas and that it is difficult to transport by hand over long distances (especially for households without their own transport). Several households also complained that it is more difficult to store gas as its canisters are bulkier and take up more space than other energy sources.

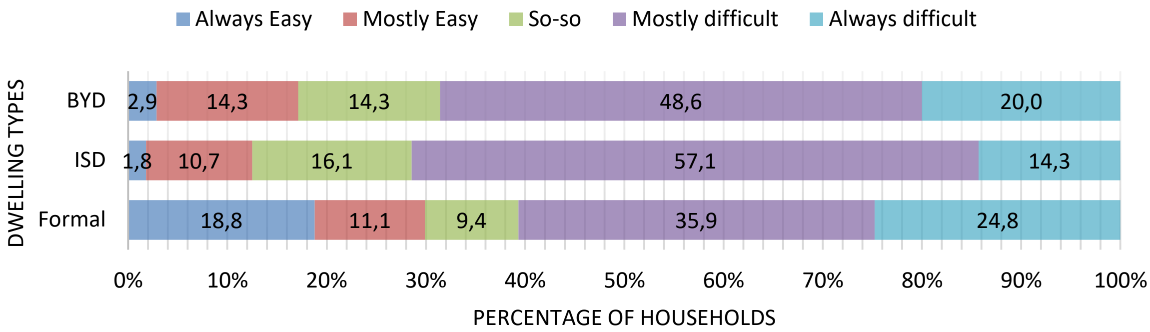


Figure 38 Household perceptions on accessibility of gas (n=247)

While gas is seen by some residents as a very efficient source of energy, discussions with residents revealed a great fear of gas, with many households worried about leaks from a cylinder or an appliance – an invisible hazard which, if not detected, could cause a fire from a single spark. This fear is a particular concern among people living in ISDs and BYDs, who are aware that their informal wiring often caused small sparks which they believe could make contact with gas and cause an explosion. Many ISD and BYD households mentioned a recent gas explosion which killed an ISD household of six in March 2017. The household survey data showed similar negative perceptions of gas with 36.1% of households surveyed rating the danger of gas as '*high*' and another 38% as '*very high'*. In households who utilised gas frequently, they recognise the potential danger of gas, however most state they felt quite safe using it. Several residents interviewed stated that they believe gas appliances to be very safe to use and less prone to problems like 'explosions' and spouting flames like paraffin-based stoves and heaters.

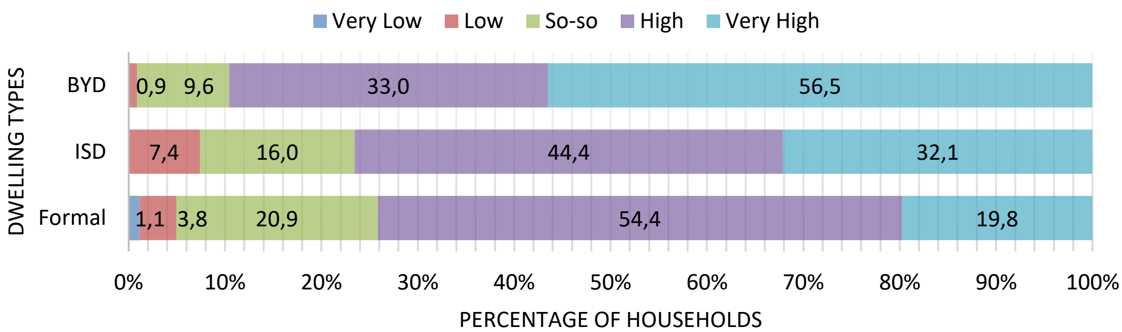


Figure 39 Household perceptions on level of danger of gas (n=496)

5.3.2.4 Firewood and coal: few attractive qualities due to its cost, poor accessibility and potential danger

Similarly, to gas, perceptions of the affordability and accessibility of firewood and coal vary amongst dwelling types. Due to the minority of households that utilise it, as well as its infrequent use by those who do, most households are uncertain of its costs. Of those who knew its cost, 58.1% of households thought the cost of firewood fuel to be '*so-so*'/neither affordable or expensive, with only 3.2%

believing it to be '*expensive*' (see Figure 39 below). For coal, fewer households perceive its affordability as '*so-so*', while a greater proportion, between 26.7% and 33.3% consider it as '*expensive*', and 7.9% of formal households considering it to be *'very expensive'.* Similarly, most households perceive coal and firewood as a somewhat difficult or '*so-so'* to access (see Figure 40), which is probably due to the relatively low demand for firewood or coal as it tends to be utilised by some households on special occasions.

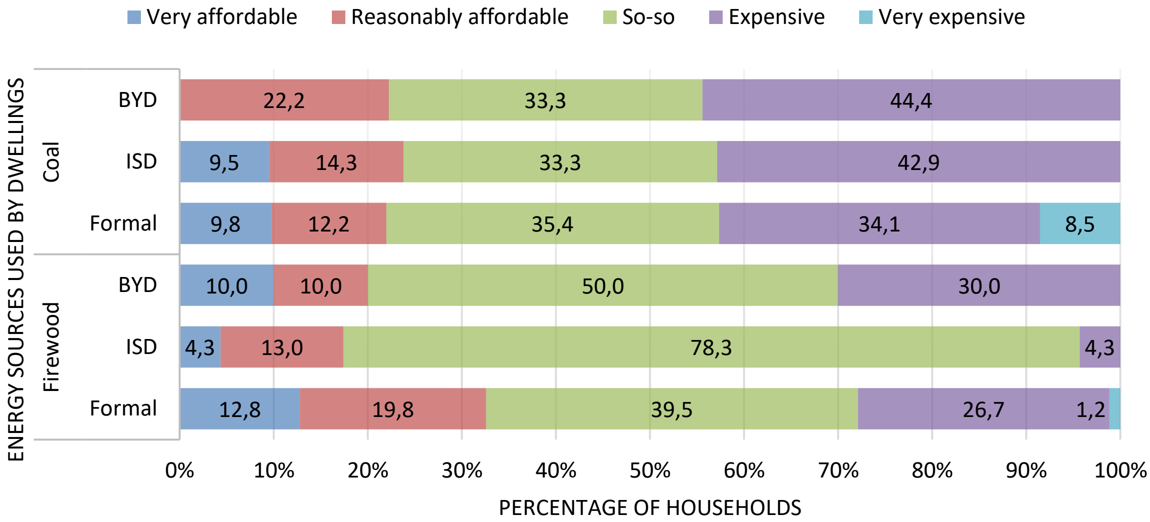


Figure 40 Household perceptions on affordability of coal and firewood (n=146)

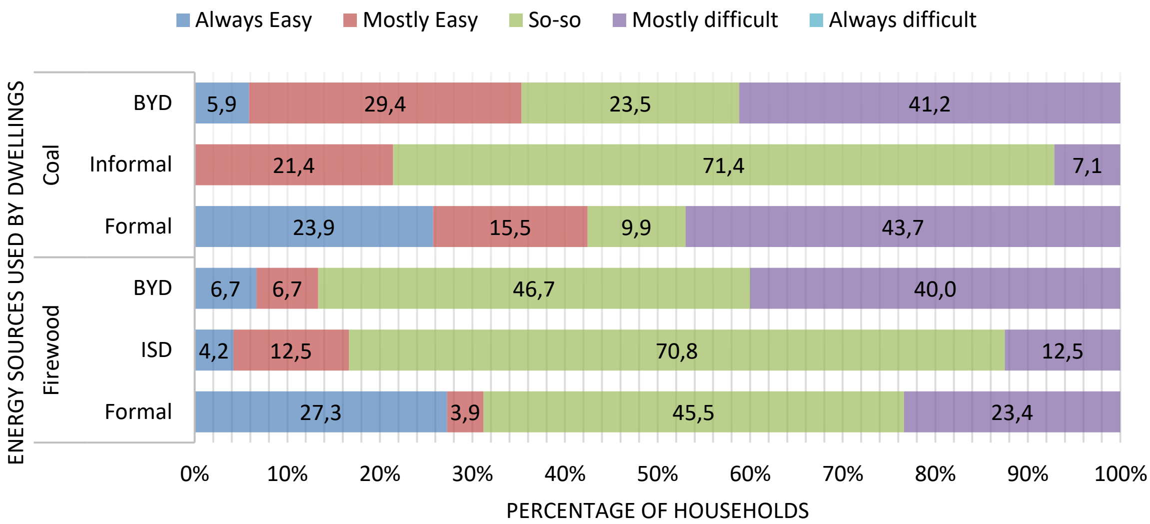


Figure 41 Household perceptions on accessibility of coal and firewood (n=150)

Household perceptions of danger associated with the burning of fuels such as coal and fire wood for energy varied according to dwelling type. Residents of formal dwellings and ISDs are mostly divided between those who believe it to be safe to use, versus those who believe it is dangerous and a major fire hazard. The clear majority of BYD households, over 65% as shown in Figure 41, believe coal and firewood to be of low danger. Their rationale for this belief is that these fuels are burned in an mbawula, or secure fireplace and are mostly used outside the dwelling. The only time these energy sources are considered a major threat are when they are used inside the dwelling, where a spark and embers could set fire to objects in the dwelling.

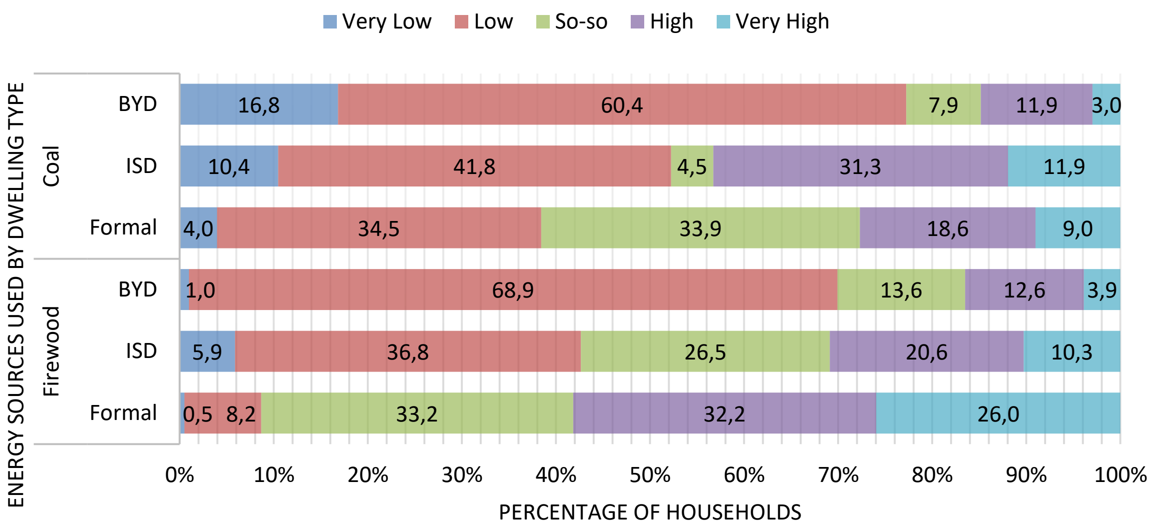


Figure 42 Household perceptions on level of danger of coal and firewood (n= 369)

5.4 ENERGY-RELATED HAZARDS CONTRIBUTING TO HOUSEHOLD FIRE RISK

5.4.1 Counting fire incidents caused by energy sources

Most households and residents engaged with during household interviews and focus groups reported that they had never experienced or been impacted by a fire incident during their time in the study site. According to the household survey as depicted in Figure 43, 129 households (24.3% of households in total surveyed) stated they have experienced at least one fire while residing in the study site. It was observed from both the qualitative research and the survey data that a greater proportion of ISD households have experienced fires over other dwelling types.

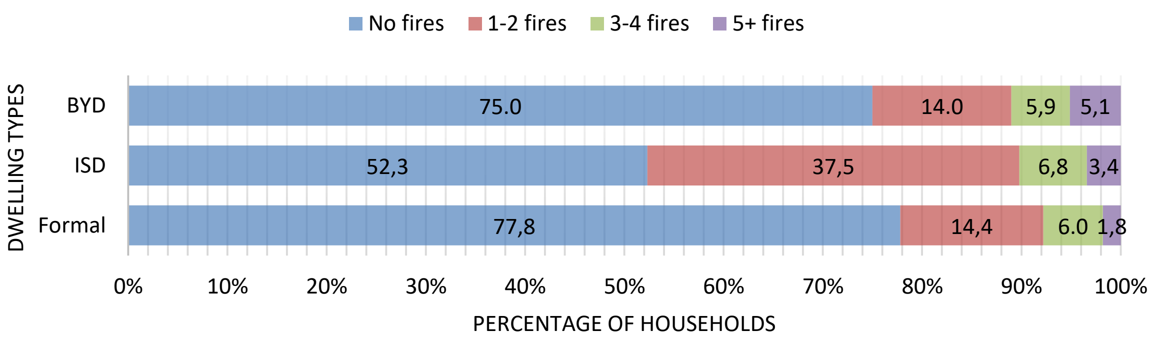


Figure 43 Number of fires experienced by households (n=508)

The household survey attempted to capture data on fire incidences experienced in the study site. It was challenging to acquire this data, especially for older fires, as residents had either recently moved to the study site, are uncertain as to the exact details of the fire, such as dates or causes of a dwelling fire. Causes of fire incidences experienced by residents varied greatly, with no particular cause being predominant; for this research, the top five causes will be examined and elaborated upon. It should also be noted that these fires varied in size and damage incurred – some are small ignitions that are put out quickly with little or no damage or injury incurred, while some others became large and either caused significant damage or totally destroyed the dwelling and or caused ma

Overall it was observed that the majority of dwelling fires recorded have been caused by non-electric energy sources, most commonly paraffin or candles. This finding appeared to mirror the perceptions of the high level of danger that residents associated to these two particular energy sources in section 5.3.2. However, it is interesting to note that the majority of fires caused by non-electrical energy sources were not related to problems with a device, such as a malfunctioning paraffin stove. As will be seen in the list of reported causes of fire, the majority appear to have occurred due to accidents caused by negligent and or irresponsible human behaviour whilst utilising such an energy source. For example, according to the survey data displayed in Figure 44, alcohol-related accidents have been the leading cause of fire incidents across households. The qualitative research suggests that these fires usually involved accidents such as knocking over burning items such as candles or paraffin stoves. In one interview, a resident admitted that he accidentally started a fire his ISD when he was drunk and kicked over his paraffin stove. Interviews with both the Strand Fire Chief, and the Disaster Manager of the Helderberg district also identified intoxication as major contributor to fires in the area.

The second most common cause of household fires involved candles. Most households stated that fires occurred from candles being overturned or knocked over. One resident stated that that her child was studying for her exams and accidentally knocked over the candle onto her notes.

The third most common cause of fire involved cooking accidents in the dwelling. Many of these cooking accidents occurred because a paraffin stove had fallen or been knocked over. Approximately 10 residents stated that that a fire had begun in their respective dwellings because a paraffin stove had fallen over whilst unsupervised, starting a fire before the residents were aware it was happening.

The fourth most common cause of fire experienced involved a leak from a gas cylinder/appliance. Several of these gas 'explosions' would occur as the resident of the house was preparing to cook, lighting a match, unaware that gas had been leaking for some time, hence causing the ignition and explosion. Almost half of these residents stated that they had experienced the explosion whilst in the middle of cooking. Several residents who had experienced gas explosions were not certain as to the cause of it as they were not nearby or operating the gas when it exploded. One stated that he and his family were asleep when the gas stove, as described by resident, "exploded". However, he suspects that the gas was not switched off properly and that the leaking gas was ignited by a spark from wiring in his dwelling.

The fifth most common cause of fires was related to children being left unattended with something flammable. Several residents retold incidents where their young children grabbed or knocked over candles. One stated that a fire had burned down their house because her children had attempted to cook something on the paraffin stove, unaware of how to place paraffin in the stove properly and accidentally spilled some over the floor. Some residents also stated that kids “get naughty with fire” stating how they may start playing with things like matches and create a fire that gets out of control. One resident stated that she had caught her children singeing the edges of curtains and putting them out as a part of a game. They cried for help when the one curtain’s flame grew beyond their control and their parents came in to put it out before causing too much damage.

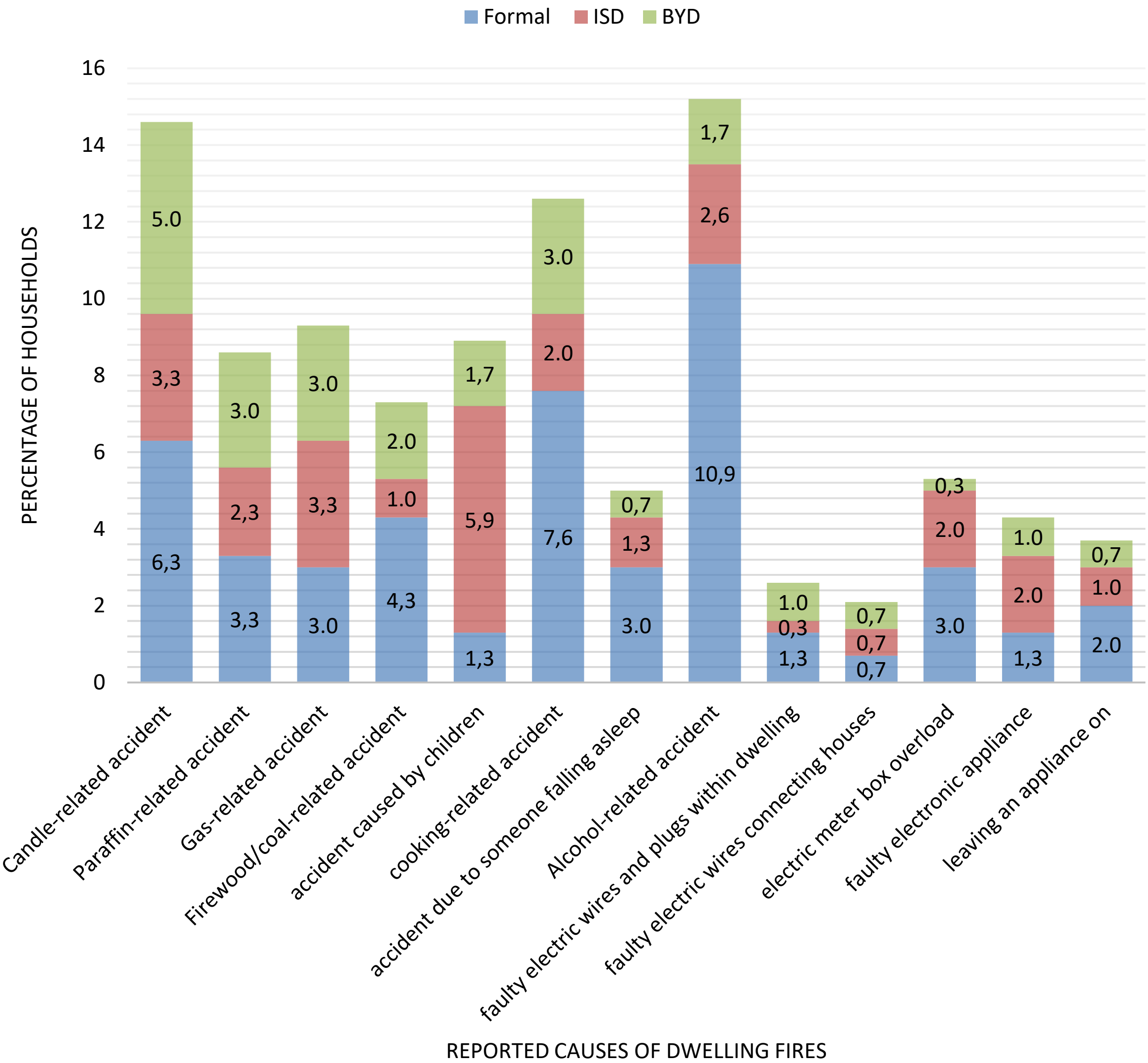


Figure 44 Reported causes of fires by households who have experienced one or more fire incidences (n=303)

As observed in the statistics, different dwelling types experienced different causes of fire more frequently than others, for example, alcohol-related incidents were reported more frequently among formal dwellings, while ISDs reported more cases of fires starting because of a child left alone with something flammable. One thing that should be noted among the ISDs is that many of the fires they experienced did not start in their own dwelling – the ignition of the fire occurred in another dwelling, but the fire spread to their dwelling. This presented challenges with respect to documenting the source of many dwelling fires, as some of the affected residents were uncertain as to the actual cause of the fire. It can also be noted that the perceived common causes of fire are very similar to reported cases, specifically that non-electric energy sources appear to be the greater contributor to fire incidents than those that involve electrical sources.

Unsurprisingly, fires caused by electric sources such as faulty wiring or appliances made up a minority of reported dwelling fires by surveyed residents. This finding appeared to mirror the perceptions reported by residents that electricity is a safer energy source than other energy sources. However, despite being fewer, electric-based fires reported by residents still made up 19.21% (44 of 229) of the reported dwelling fires in the survey. As can be seen in Figure 44, electric fires were found predominantly in formal dwellings, shortly followed by ISDs. Many formal and informal residents stated that fires are often caused because of utilising too many electric appliances at once, causing trips which damage the circuitry of appliances and wiring which results in sparks which ignite nearby flammable objects. One resident stated that they almost had a fire the night before being interviewed because an extension cord and plug running directly beneath their mattress had (presumably) overheated and had started to burn it. Despite being told during interviews and discussions that faulty electric wiring, particularly along informal connections running between ISDs and BYDs, was a major danger and a common cause of fire, only a handful of households reported experiencing a dwelling fire from such a cause.

In addition, while there were only a few electricity-based fire incidents recorded, there was a slight increase in the number of such incidents over the years (as shown in Figure 45). It was found that in 2013, 2015 and (within the first five months of) 2017, electricity-based fires made up approximately a third of all fires in those years, which could possibly indicate a potential rise in the frequency of electricity-related fires in the study site.

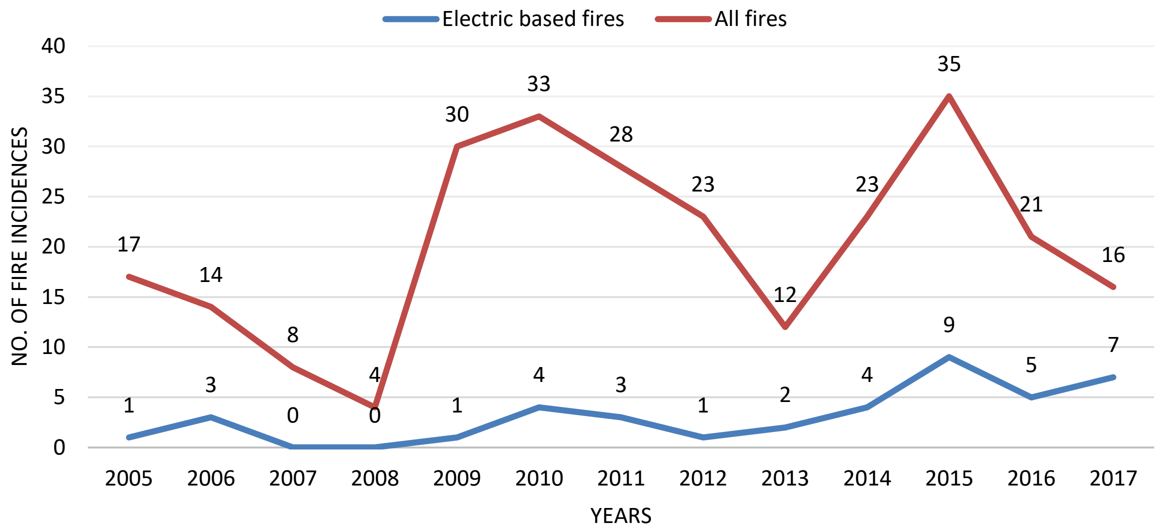


Figure 45 Increasing number of electric-based fires occuring in study site (n=304)

5.4.2 Comparing survey observations with CoCT data on fire incidents in the study site

Some similarities and trends could be observed between fire incidences reported in the survey and fire incidents recorded in the CoCT fire incident data for Lwandle, Nomzamo and Asanda, as can be seen in Table 4. It should be noted that the findings between the two are not wholly comparable. The CoCT fire incident data reflects dwelling fires reported to the Fire and Rescue Service, and to which they responded. The dwelling fire incidents documented by the thesis survey included both large fires that the fire department would have responded to, and smaller fires that were quickly put out and did not warrant reporting to the Fire and Rescue Service. It should also be noted that the questionnaire often gathered information long after the fires occurred, requiring residents to remember specific details from events that may have occurred years before. Hence the accuracy of this information could be influenced by human error and recall issues.

Like the household survey findings, the majority of dwelling fires, according to the fire incident data, appear to be caused by a non-electric energy source (Western Cape Government 2017) such as burning candles, paraffin and gas stoves, and from smouldering firewood and coals brought indoors (usually placed in an mbawula). The survey findings on gas-related fires between the thesis findings and the CoCT database differed substantially. While only three incidents were reported in the City's data, the household survey recorded 28 instances. In the CoCT database, each of the gas-related accidents caused a large fire that destroyed several dwellings, while the majority of this thesis's documented gas-related fires are small accidents such as gas stoves being knocked over, flammable items catching alight or mini explosions caused by small leakages of gas, in which all but two were easily extinguished before a serious fire occurred. As mentioned before, these smaller non-destructive fires did not warrant the calling of the fire department and hence had not been recorded.

Another interesting divergence in trends between the two sets of data is the high number of fires related to electric sources and appliances. Both the thesis data and CoCT database found electricity to be the cause of a minority of fires recorded (19.2% and 16.5 respectively). The CoCT database shows the majority of dwelling fires among formal dwellings (66.7%) are caused by an electrical source. Even including indeterminable fires, fires caused by electric sources make up a surprising proportion of formal dwelling fires (31.6%) within the CoCT database, as can be seen in Table 4. This finding is particularly interesting as the majority of electric fires reported by the CoCT database had caused much damage to households, even destroying whole dwellings, while the majority of electric fires reported by residents in the thesis caused only minor damage (i.e. damaging furniture and clothing). Another correlation observed between the thesis and database findings was that both sets of data showed a slight increase in the number of dwelling fires caused by electric faults from 2013, as shown in Figure 46.

Table 5 Comparing information from CoCT fire incident database against findings of thesis household survey concerning fire incidents (Western Cape Government 2017)

Source of fire	CoCT fire incident database		Thesis household survey	
	Formal dwellings	Informal dwellings	Formal dwellings	Informal dwellings (ISDs & BYDs)
Candle-related accident	4	29	19	25
Paraffin-related accident	2	32	10	16
Gas-related accident	0	3	9	19
Firewood/coal (mbawula)	1	9	13	9
Accident caused by children	2	2	4	23
Accident while cooking	3	22	23	15
Electric sources and appliances	24	37	25	19
Undetermined cause	36	164	N/A	N/A
Totals	72	298	103	126
	370		229	

Figure 46 Increasing frequency of electric fires observed in study site according to CoCT fire incident database (n=370)

5.4.3 Combatting household fire risks through personalised risk reduction initiatives

As examined earlier, majority of residents of the study site recognise that the non-electric energy sources they use are potential fire hazards, which may threaten to cause a fire because of an accident, irresponsible usage or an appliance fault. Consequently, many households have attempted to reduce their usage of such energy sources, employing them as little as possible and using electricity in its stead, in order to reduce their dwelling's fire risk. There are a number of households that refuse to use non-electric energy sources unless it is for an emergency, i.e. using candles during a power failure.

However, for many households, reducing their usage of non-electric energy sources to attempt to reduce their risk to fire is not an option. Many households in the study site are constrained by limited financial resources and poor quality electrical connections, forcing them to resort to alternative non-electric energy sources. Even if households had improved access and increased financial resources to afford to rely solely on electricity, as has been observed in sections 5.4.2 and 5.4.3, fires caused by faulty electric equipment, wires and/or overloading the electric system may too result in dwelling fires, be it within a formal or informal structure.

Although most households have little option other than to utilise these potentially hazardous sources, engagement with residents during household interviews and focus group sessions[3] identified several

[3] The researcher believed it was better to document these mitigation strategies through qualitative interview sessions were residents could explain and even physically demonstrate their strategies. It was felt that a

specific measures employed by households to attempt to mitigate their risks to fires, which include one or a combination of the following:

i. ***Using a minimum of electrical appliances simultaneously:*** many households, especially BYDs and ISDs stated that one should be careful not to use too many electronic appliances simultaneous as it increases the risk of causing plugs and wires to overheat, the electricity to trip as well as damage to the meter box. Consequently, many households try to keep the number of electronic appliances being used simultaneously to a minimum, especially during times when cooking with electronic appliances, which consume a lot of electricity.

ii. ***Check and maintain all appliances and connections***: many households, especially BYDs and ISDs, mentioned they would frequently check on and maintain their electrical connections and appliances. This behaviour included applying protective tape around loose wires, and fixing and replacing broken wires and plugs. They also checked and maintained non-electric appliances too, such as gas heaters and paraffin stoves. Several households stated that cleaning paraffin stoves frequently made them more reliable, less prone to 'choking' or spurting out flames.

iii. ***Keep away from flammable objects***: the majority if not all households try to keep any flammable objects such clothing, curtains and furniture away from energy-based appliances, in particular those using non-electric sources such as gas and paraffin stoves. Among BYDs and ISDs, people tried to ensure that wires do not run beneath beds and furniture and clothes. Most households try to position wiring on the ceiling to avoid touching.

iv. ***Switch off and/or disconnect:*** a commonly employed approach used across all households was to ensure all electrical appliances are properly switched off when not in use, especially when no one is in the house. Among many BYDs and ISDs, residents are able to disconnect their whole dwelling from their source of electricity. For BYDs, many residents, before leaving the dwelling, would unplug themselves or inform their landlord so they could unplug them. Similarly, residents in ISDs disconnect themselves by detaching the wire/s that carry the electricity to the dwelling when necessary.

v. ***Proper ventilation to reduce accidents due to adverse symptoms of emissions:*** as mentioned in section 5.3.2, an issue raised by residents was that breathing in paraffin or firewood emissions/smoke could make people unwell and disoriented, increasing the risk of them causing an accident such as knocking over an operating paraffin stove. Consequently, several households iterated the importance of properly ventilating their dwellings to ensure the

structured questionnaire would prevent nuanced description of residents' mitigation strategies. An unfortunate limitation to these findings are that no quantitative data on mitigation strategies was collected to measure, for example, how many residents employ particular strategies.

dwelling is not inundated with fumes, and thereby reduce the risk of becoming unwell and causing an accident.

vi. ***Safety during power cuts****:* if electricity is cut because of a power trip, load shedding or because of running out of electricity, many households ensure that all electric appliances are switched off, especially if they were switched on during the power cut. This behaviour is to ensure that if the power comes back on while the household members are out, the appliances do not turn on and continue operating unsupervised.

vii. ***Protecting and educating children:*** many households prioritised keeping candles, matches, paraffin and electric stoves out of reach of children – this also included not leaving children alone in the house or unsupervised. For households that used paraffin stoves for heating in winter and candles for emergencies, they suggested hiding or locking up these things so that children could not access them. Similarly, households stressed the importance of teaching children from a young age not to play with flammable appliances and forbidding children from using candles and flammable appliances unless supervised, as well as teaching children how to use these safely.

viii. ***Safety during cooking:*** cooking was noted by many as a potentially dangerous activity. Households reported that there should always be someone supervising cooking. One respondent noted that he does not cook when he is drunk or hungover, in case he passes out and leaves the stove on.

ix. ***Community vigilance:*** in informal residential areas of the study site, a form of risk reduction comes from strong community ties and vigilance for fire. Due to the high risk of fires occurring among these areas, and the risk of fire spreading quickly to surrounding dwellings, community members are often on the lookout for signs of fire. Therefore, neighbours often watch out for one another to give warning if a fire breaks out and give aid to fighting the fire if necessary.

Residents revealed during discussions that while they are aware that though such measures do not necessarily make their energy sources less of a hazard or less dangerous, employing these risk reduction strategies on a daily basis make them feel significantly more “in control” of these energy sources, and therefore feel safer and less fearful of fire.

While it appeared that many households employed some form of measures to enhance household safety, some did not. A lack of measures to mitigate fire risk was observed in households that used electricity predominantly, in particular those residing within formal dwellings. Residents of such households tended to state they did not have or practice any risk reduction strategies because they felt safe using electricity and there was therefore no need to undertake risk reducing practices.

Interestingly, officials from the local Fire and Rescue Service and disaster management both mentioned the absence of a "culture of safety" with respect to fire in local communities (Maunel & Van der Westhuizen pers. comm. 2017). They stated that fires are predominantly caused by irresponsible and negligent human behaviour and actions. These included people leaving appliances operating unattended or with inadequate supervision (i.e. with a child or someone who does not know how to operate the appliance and energy source properly). Another major issue raised by both institutions was the issue of people using energy sources and appliances while intoxicated, particularly over weekends. Given the preceding findings, however, this perhaps highlights a lack of engagement between community members, emergency services and disaster management, with officials unaware of the effort that significant parts of the community make to reduce their fire risk.

6 DISCUSSION AND CRITICAL ANALYSIS OF FINDINGS

6.1 INTRODUCTION

This thesis examined energy preferences and choices amongst households in Lwandle, Nomzamo and Asanda Village in Somerset West in Cape Town, and the implications for fire risk. Specifically, it explored the energy sources used, including whether households with access to electricity adopt this as their preferred source; the factors influencing energy choices; and how energy choices might contribute to the risk of fires. This section discusses and summarises the central findings of the research, compares these to the literature on energy preferences in poor communities, and draws out the potential implications of the findings for policy and disaster risk reduction. The first part of this section will analyse the trends of household energy use in the study site and compare them to similar studies on energy usage among low-income households in Cape Town and South Africa. The second part of this section looks at factors such as financial limitations and poor levels of accessibility influencing energy usage. The third part will observe fire incidences experienced and analyse how the factors mentioned above may influence fire risk in households.

6.2 HOUSEHOLD ENERGY USAGE: PREDOMINANCE OF ELECTRICITY AND ENERGY STACKING APPROACH

It is evident from discussions with residents and data from the household survey that electricity is the preferred energy source utilised by households across the study site for activities such as lighting, cooking and boiling water. These findings parallel the observations made by other reports in South Africa, such as the CoCT SoE 2015 Report, the DoE 2012 'Survey of energy-related behaviour and perceptions in South Africa: the residential sector', and the 2013 South African General Household Survey which state electricity is the primary source of energy among all low-income urban households (CoCT 2015; RSA 2012b; RSA 2014). The preference for electricity can be attributed to perceptions regarding its accessibility, affordability and versatility. Both the qualitative and quantitative research also suggest the households perceive electricity to be safer than other energy sources. Energy sources such as paraffin, gas, fire wood, coal and candles are viewed as dangerous and considered the main culprit for residential fires in the area.

However, despite the widespread view among residents of the study site that these energy sources are dangerous, the majority of households continue to utilise these fuels on a frequent basis. While electricity was the predominant energy source for most households in the study site, two thirds (67.2%) of households in the study site employ an energy stacking approach, utilising a variety of (usually non-electric) energy sources, to meet their energy needs. This finding mirrors observations by van der Kroon et al. (2011) and Uhunamure et al. (2009) who observed that energy use in low-income households does not tend correspond to the energy ladder approach to energy usage, where households transition hierarchically from primitive energy sources such as wood to transitional sources such as paraffin and candles and through to advanced sources such as electricity – the implied assumption being that people will adopt more advanced sources when they become accessible.

However, the research suggests even greater complexity than suggested by the energy stacking model. As Figure 47 below shows, households participating in the research used a combination of primitive, transitional and advanced energy sources (indicated by the green dotted line). Households often use a combination of transitional and advanced sources, such as paraffin, candles and electricity, on a frequent if not daily basis. Some of these households are also known to utilise primitive sources such as firewood for heating or for cooking; such primitive sources tend to be used amongst only a minority of households and infrequently, usually only for special occasions such as holidays or family gatherings. This overlap is represented in Figure 47 by the area bordered by the red dotted line. The majority of the surveyed households (67.2%) fall into this category, as they adopt a mixed energy use, or energy stacking approach, on a regular basis. Those 32.8% of households who almost always use electricity to meet their energy needs, would be located within the blue dotted area.

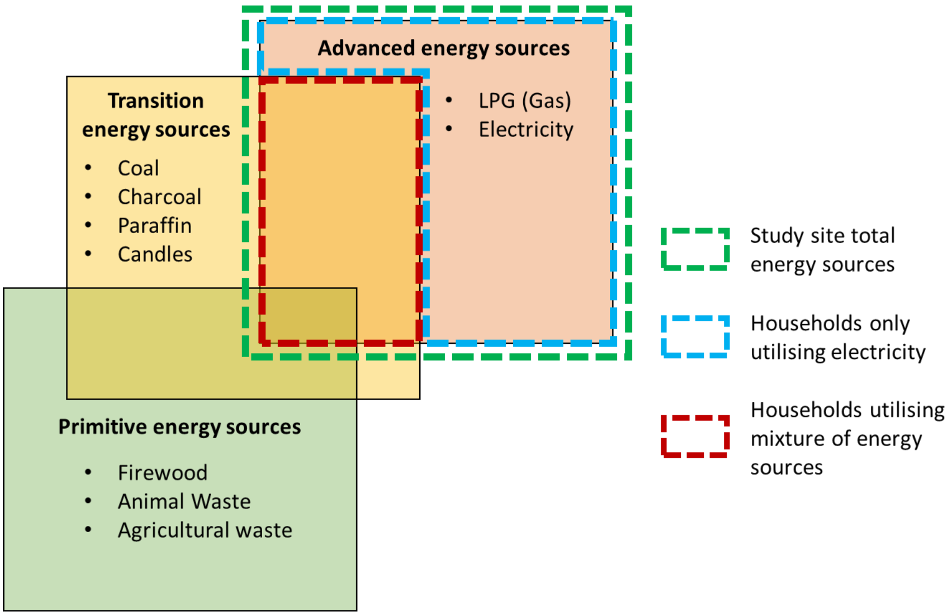


Figure 47 Location of study site households within the energy stacking model

It can be argued that no households in South Africa rely exclusively on advanced energy sources, because they may, from time to time, use transitional or even primitive energy sources during, for example, power cuts or social gatherings. However, in the context of low-income residential areas like Lwandle, Nomzamo and Asanda Village, while there are some households that can choose to utilise electricity as their predominant energy source there are many households who have no choice but to use a range of energy sources. Such households, located in the red dotted zone, are often faced with a number of obstacles (to be elaborated upon in section 6.3), which leave them little option but to rely on an energy stacking approach to meet their day-to-day energy needs.

Paraffin was observed to be the most commonly utilised energy source after electricity, being used as an alternative for activities such as cooking, boiling water and heating, particularly during the winter months, as it can be used for all three tasks. Candles are still frequently utilised for lighting when electricity is unavailable. Some households utilise firewood and coal for cooking or heating, but more infrequently. Gas was not widely utilised by households in the study site.

The thesis's observations of households' use of an energy stacking approach is in keeping with the finding of the DoE's 2012 energy survey for the residential sector. While electricity remains the predominant energy source utilised for various household activities, most low-income urban households observed employ non-electric energy sources frequently as alternatives to supplement their energy needs for cooking, lighting and spatial heating. With regards to spatial heating, both this research and DoE report found that many households did not utilise any energy sources to heat their dwellings. This finding was largely because some energy sources are considered too expensive (i.e. electricity) and, in some cases, too risky (i.e. paraffin). Consequently, such households opted rather to wear warmer clothing and/or use extra blankets to keep themselves warm within their dwellings.

Both the thesis and the DoE Report also observed that formal households tended to utilise energy stacking approaches less frequently than informal dwellings. For example, formal households are more likely to rely on solely electricity for cooking and boiling water, while informal dwellings were more likely to use a combination of electric and non-electric energy sources such as paraffin and gas. This finding is attributable to greater accessibility to high-quality electrical connections and services comes greater usage of electricity over non-electric sources. However, in contrast to this DoE report, which found that only a minority of urban informal dwellings solely use electricity, the findings of this thesis suggest that energy choices of BYD based households are more similar to those in households living in formal dwellings and ISDs. While ISDs in the study site tend to rely on non-electric energy sources and utilising an energy stacking approach, BYDs primarily use only electricity to meet their energy needs. It was rather surprising that to find from the household interviews and especially the questionnaire data that BYDs were less likely to employ a mixed energy approach than households based in formal dwellings (see Figure 21, Section 5.2.1). There are several explanations for this unexpected finding. Most BYD residents, like most of those living in ISDs, dislike using non-electric energy sources due to the threat of fire within their predominantly wooden, small and cramped dwellings. There is limited space for them to operate any non-electric devices without the risk of something (i.e. furniture, bedding, curtains, etc.) igniting and causing a fire. On the other hand, residents of formal dwellings appear to feel more confident utilising non-electric energy sources. There is more space to operate non-electric devices safely, and dwellings built predominantly with brick and concrete, and often with tiled floors, are less flammable than informal structures.

Unlike ISDs BYDs, being located within the properties of formal dwellings, by the researcher's observation tend to have access to more reliable, secure and better maintained (i.e. wiring which was properly covered with insulation) sources of electricity. Unlike ISDs, electricity is not shared across dozens of households, but is only shared between the formal dwelling and a handful of other BYDs. This places less strain on the electricity supply and power is less likely to trip. It was also observed that because most BYDs are small, have fewer occupants, and own fewer electricity consuming devices such as refrigerators, freezers, washing machines, geysers, etc., they tend to consume less electricity and can therefore afford it (as often part of their rent to their formal dwelling landlord). Conversely, formal households tend to be larger and own more electricity consuming appliances. This may make electricity less affordable, resulting in the adoption of an energy stacking approach (this will be discussed further in section 6.3.1).

6.3 FACTORS INFLUENCING HOUSEHOLD ENERGY USAGE

It would appear that while most households have access to electricity and it is their preferred choice of energy against what they perceive as more dangerous energy sources, many continue utilising other sources due to issues of affordability and accessibility.

6.3.1 Affordability of energy sources

For many households, electricity is considered expensive. Lloyd (2014a) has made a similar observation in which the high cost of electricity, especially electrical appliances, bars many poor households from utilising electricity for many essential activities. Often households feel they could not afford to purchase the amount of electricity necessary to meet their energy needs. Consequently, households alternate between electricity and other non-electric energy sources, depending on the financial situation of the household at the time; when money is running low, households may resort to using less costly alternatives such as candles for lighting and paraffin for cooking.

These strategies mirror research by van der Kroon et al. (2011) and Davis (1998), which showed that poor households use a variety of energy sources and alternate between them in response to financial insecurity and uncertainty. Lloyd (2014a) and other researchers have made similar observations that low-income households in South Africa resort to using energy sources such as paraffin and candles when households wish to save money (Kovacic et al. 2016; Mehlwana 1997; SEA 2015; Ismail 2015).

It was generally observed that households with higher incomes tend to utilise mostly electricity and electric appliances to meet their energy needs and rely less frequently on other non-electric sources than those with lower incomes. It would appear that these households (those with higher income per capita) feel there is less pressure to resort to using non-electric energy sources due to financial constraints and thus feel able to use more expensive energy sources like electricity and its associated appliances. These observations appear to reflect some of the perspectives of Keller (2012) concerning energy stacking behaviour, who believes that increased economic resources allow households greater opportunity for them to select their preferred choice of energy – usually more advanced forms of energy such as electricity.

6.3.2 Accessibility of energy sources

Despite most households having physical access to electricity, the quality of connections varies. As noted already, formal households generally have high quality connections, while the informal connections used in BYDs and ISDs are of a poorer quality, and are less reliable and safe. BYDs are usually one of several households utilising a landlord's electricity, and depend on the goodwill of their landlords to supply them. They are also restricted from using too many appliances in their dwelling, to avoid placing pressure on their connections, and causing power outages or damage to the connections. ISDs share similar limitations due to sharing power with multiple households. The poor quality of these connections encourages energy stacking.

As discussed already, paraffin is versatile and readily available, making it a popular alternative to electricity. The ability to borrow, share and transport paraffin easily among households, as observed in the research, mirrors an observation by Lloyd (2014b) who speaks of paraffin as a "social fuel", hence contributing to its popularity and high usage among low-income households. Paraffin has been found to be particularly popular during the winter, as it serves to provide energy for cooking and spatial heating simultaneously. Examining data on paraffin sales between 2001 and 2008, Truran (2009) showed annual increases in paraffin sales between April and September. According to residents, paraffin becomes more difficult to access at this time of year as increasing demand for paraffin outstrips supply, causing shortages in spaza shops as well as increases in prices which makes it more difficult to afford.

6.4 IMPLICATIONS OF ENERGY USE FOR HOUSEHOLD FIRE RISK

6.4.1 Non-electric energy– the old enemy

In keeping with the literature on dwelling fires in low-income areas in South Africa, this thesis's findings suggest that non-electric energy sources are the most common cause of dwelling fires amongst the households surveyed. A common issue raised in community risk assessments carried out by DiMP/RADAR was that paraffin and candles were known to be responsible for a number of fires across various low-income settlements, particularly ISDs (DiMP 2010; DiMP 2011; DiMP 2012; RADAR 2014). Candles are perceived as particularly dangerous, which show a high proportion of households claiming to feel unsafe using them (see also CoCT 2015; Swart & Bredenkamp 2012). Similarly, paraffin is commonly cited by both residents in the study site and by other researchers as being a highly dangerous fuel and a major contributor to fires. The households' description of frequent spouting of flames, mini 'explosions' and general accidents appear to concur with other research, which suggests that the inferior quality appliances used by many low-income households are prone to malfunctions, as does inadvertently utilising polluted paraffin (Truran 2009; Kimemia & van Niekerk 2017; Harte et al. 2009).

As mentioned previously, gas is rarely employed by households in the study site, primarily due to households' perception that it is dangerous. Most households are distrustful and fearful of gas, with many refusing to utilise it, fearing the invisible threat of a gas leak, causing a possible explosion. Research by Lloyd (2014a; 2014b) and Mohlakoana and Annecke (2008) identified similar sentiments of distrust and fear of gas among low-income households, despite efforts of gas suppliers and local government to promote it as a safe energy source.

According to the household survey, accidents involving the knocking over of paraffin stoves, candles and leaving appliances burning unattended is commonly attributed to alcohol and intoxicated behaviour of household members. These findings mirror observations of dwelling fires in Cape Town made in other research and reports (Van Niekerk et al. 2009; Western Cape Government 2016; Harte et al. 2009). Discussions with the Strand fire station chief and firefighters (the closest fire station to the study site) and Helderberg disaster risk manager confirmed that alcoholism and intoxication was a major contributor to fires in the area (Maunel & Van der Westhuizen pers. comm. 2017).

Household perceptions and actual experiences of causes of fires reported by residents mirror the trends of dwelling fires recorded by CoCT fire incident database for Lwandle, Nomzamo and Asanda to a degree. Both the thesis and the CoCT database observed that non-electric energy sources are the greatest cause of (known) dwelling fires in the study site, however, the thesis and the dataset findings diverge significantly regarding the causes of fire within particular dwelling types. The CoCT dataset suggests that non-electric energy sources contribute only to a minority of fires in formal dwellings. Such findings would conform to the paradigm that increased access to formal electrical infrastructure would decrease exposure to flammable energy sources and reduce risk of dwelling fires because of their reduced usage (CoCT 2015; Louw, et al. 2008; Albertyn, et al. 2012). The thesis findings reflected that non-electric energy sources are the main cause of fires in formal dwellings and possibly occur more frequently than the CoCT dataset suggests.

The reason for the high incidence of non-electric based fires in households might be linked to issues concerning limited financial resources and a lack of access to reliable and stable electric connections in informally connected households (Davis 1998; Uhunamure et al. 2009; Kroon et al. 2011). As observed in the thesis findings, non-electric energy sources are utilised frequently by most households, even formal dwellings, to act as alternatives when electricity is unavailable financially or physically (i.e. power cuts from overloading or physical disconnections). Consequently, many households, regardless of dwelling type or whether they have formal or informal access to electricity, are at risk to dwelling fires because of their continued reliance on non-electric sources to meet their energy needs.

However, despite households being exposed to these potentially hazardous energy sources, most households reported taking active measures to mitigate their risk of experiencing a dwelling fire. These strategies included vigilance, keeping flames away from flammable household objects, educating children about the dangers of fire, and keeping children away from potential sources of harm. Many residents stated that as long as they were careful, vigilant and responsible when using such sources, though they continue to utilise potentially hazardous energy sources, they feel less at risk and significantly safer while using them. Such sentiments by residents would appear to resemble Truran's (2009: 9) argument that "the danger is not so much paraffin per se but rather the unsafe system of paraffin use", reiterating the idea that non-electric energy sources like paraffin are not necessarily dangerous, but that it is how people use them that makes them dangerous.

6.4.2 Electricity – the safer energy option?

The majority of households viewed electricity as significantly safer than other energy sources. The CoCT SoE 2015 report and other research shares similar sentiments that increased electrification is key to reducing dangerous fuels such as paraffin which are linked a number of residential fire incidences (CoCT 2015; Louw, et al. 2008; Albertyn, et al. 2012; Spalding-Fecher 2005). While most households thought electricity reduced the risk of fires, a small number of households felt that electricity presented its own threats. Though electricity was deemed less of a fire risk than non-electric sources, it was still responsible for a small yet significant amount of fires in the study site. Faulty electric wiring in dwellings, as well as overloading caused by providing electricity to BYDs, have been reported in formal residential areas of the study site. Similarly, sparks and overloading from informal electrical connections among informal settlements were reported to cause fires within ISDs.

It was observed in the thesis data that there was a slight increase in the number of electric-based fires occurring in the study site between 2014 and early 2017. Whether this result is indicative of a trend of increasing risk of electrical fires occurring in the area is uncertain, however it is interesting to note that data from the CoCT fire incident database for the study site also showed a possible increase in the frequency of electric-based fires occurring between 2013 and 2015 (Western Cape Government 2017). However, it can also be noted that according to the City of Cape Town's fire incident data base, there has been a 132% and 334.5% increase in electric-based fires among formalised and informal dwellings respectively between 2009 and 2015 (Western Cape Government 2017).

Despite the potential danger that electric connections and appliances may present to households, several residents have taken up specific mitigating measures to reduce their risk of a dwelling fire to occur. Households based in BYDs and ISDs, aware of the dangers presented by informal connections, revealed some particularly interesting strategies such as disconnecting their dwelling's electrical wires manually to reduce the chance or sparks or overheating of wiring and appliances. It seems that residents of formal dwellings are less likely to employ such measures because many do not see electricity as a hazard, and are confident in the quality and safety of their dwelling's formal electric infrastructure. As suggested by one of the households, electricity is possibly creating a false sense of security amongst residents who are so desperate to transition away from traditional sources they are overlooking some of the dangers electricity presents, hence leaving themselves vulnerable to harm.

6.5 IMPLICATIONS OF FINDINGS FOR POLICY AND DISASTER RISK

In addition to providing insight into household energy usage and the associated risk of dwelling fires, the findings have implications for urban planning and policy, service delivery and fire risk reduction strategies in the City of Cape Town, and comparable settings elsewhere.

6.5.1 Challenging assumptions about energy usage among low-income households

Documents such as the CoCT's SoE Report for 2015 paint a positive picture of energy usage among low-income households in the city. According to the report over 94% of residential dwelling have been connected to the electrical grid since 2015, the highest rate in the country (RSA 2014). While most of the households in the study site have physical access to electricity, this research shows that having access does not mean that all households can use it. The prohibitive cost of electricity prevents some households from using electricity to meet all or even part of their energy needs. The findings also show that even when households have access to electricity, they do not necessarily stop using non-electric energy sources.

The research also contests assumptions about energy use profiles among households living in different dwelling types. In the DoE's 2012 energy survey for the residential sector (RSA 2012b), for example, both ISDs and BYDs are understood as having the same energy use profile; i.e. both reliant primarily on non-electric energy sources. This research highlights that energy use in the two dwelling type varies considerably. The research also challenges the assumption that those living in electrified formal housing automatically adopt and utilise predominantly advanced energy sources. Finally, this research questions the impression that fire is predominantly an issue in informal dwellings. This thesis recognises that while informal dwellings do experience fire incidences more frequently, formal dwellings are also at significant risk.

6.5.2 Energy usage and implications for Disaster Risk

These findings have implications for fire risk in different dwelling types. It is widely assumed that the roll out of electrical infrastructure in low-income areas will assist in reducing fire risk as households shift from transitional to advanced energy sources (Louw, et al. 2008; Albertyn, et al. 2012). However, the findings of the research suggest this is not the case, with the majority of households still employing a mixture of electric and non-electric energy sources. Consequently, many households still use highly flammable and unsafe energy sources such as paraffin and candles, which place households at high risk of experiencing a dwelling fire. In addition, the research indicates that there have been a significant number of dwelling fires initiated by faulty wiring and electric appliances, suggesting the electricity too poses a fire risk.

This highlights a need for continued and holistic measures to reduce the risk of fires in low-income areas. While current efforts to reduce risk tend to focus in informal settlements, the research suggests that the potential for fires in formal housing areas needs to be better understood, and that initiatives to prevent fires need to extend to subsidised housing areas. A particular strategy advocated by the Western Cape fire services that may significantly reduce fire risk in both formal and informal dwellings is to promote legislation to regulate the design and quality of paraffin stoves, to ensure that sub-standard and inferior quality devices are barred from being sold to households (Western Cape Government 2015).

It is also essential that campaigns to raise awareness about fire-prevention include education on the dangers posed by electricity, and how to utilise it safely. A prominent area for action identified by fire services has been to reduce human and behavioural risks through improved educational and awareness campaigns to promote safe energy use practices, particularly among children (Western Cape Government 2015). Another intervention advocated by disaster management and fire services in the Western Cape is to invest in household warning systems, particularly smoke alarms (Western Cape Government 2015; Western Cape Government 2016b). The proposed implementation of such alarms among low-income dwellings may be crucial considering the prevalent usage of unsafe energy sources such as paraffin and candles, and even fires caused by electric wiring and appliances.

7 CONCLUSIONS & RECOMMENDATIONS FOR FURTHER RESEARCH

In this thesis, that households across Lwandle, Nomzamo and Asanda Village were observed using a wide diversity of energy sources to meet their energy needs. Almost all households had access to electricity, either through formal or informal connections, and it was the predominant source of energy due to its versatility and that fact that it is viewed as safer than other energy sources. Nonetheless, many households, particularly ISDs and BYDs, relied on informal electrical connections, which are less stable reliable, prone to power outages and present a fire hazard. The sharing of informal connections reduces the quality of power, constraining households' ability to utilise electrical appliances. It was also observed that the majority of households have very low and/or irregular incomes, which limit their ability to afford adequate electricity to meet their energy needs.

Consequently, due to one or a combination of these factors, it was found that many households are forced to resort to an energy stacking approach, alternating between electricity and non-electric energy sources, such as paraffin, candles, gas and sometimes firewood and coal, to provide power for their daily activities such as cooking, lighting, boiling water and providing heating for their dwellings. While some households may utilise these non-electric energy sources only a few times a week or a month to save money or during power cuts and load shedding, many other households, especially ISDs, rely on these sources almost on a daily basis because they cannot afford the cost of electricity and/or because of the instability of their informal connections.

A potential consequence of the energy stacking approach is that the majority of households continue to face the risk of a dwelling fire caused by non-electric energy sources. The frequent use of non-electric energy sources is perceived by residents as a major contributor to fires in the study site. The research shows that the majority of dwelling fires experienced by residents in the study site are caused by non-electric energy sources, particularly candles and paraffin. The danger posed by these energy sources is strongly linked to human behaviour, such as drinking and children knocking over or playing with flammable energy sources.

The findings also challenge the perception that increased access to electricity would result in reduced usage of transitional energy sources, as well as reduced risk of dwelling fire. The research shows that households living in electrified formal dwellings continue to use an energy stacking approach, suggesting a continued risk of fires in subsidised housing areas. Moreover, while it is assumed that electricity, and electrical appliances are safer, the research found a number of fires have been caused by faulty electrical wires, appliances, informal connections and overloading of plugs and electrical systems. Though electricity is less often associated with fires than non-electric energy sources, this could potentially change. The household data found a slight increase in the number of fires caused by electric sources in the study site, which appears to correspond to increased reports of similar electric-based residential fires reported by the City of Cape Town fire incident database for the study site area, as well as the Municipality as a whole. Therefore despite the presence of electrification in the study site (a phenomena that is said to reduce household fire risk), households are still potentially at risk of fire from electric sources.

While households are exposed to a number of potentially hazardous energy sources both electric and non-electric alike on a frequent basis, there is evidence that households are not as vulnerable to fire risks as would be presumed. From discussions with residents in their dwellings, it was observed that many households employ a number of specific measures, often tailor-made to meet the safety requirements of their inhabitants, dwelling type and energy sources utilised, to reduce their exposure and mitigate the potential negative impacts they could experience from them. Consequently, such measures employed by households have probably been responsible for reducing the number of dwellings fires experienced in the study site.

This research could also potentially be expanded upon to explore much more concerning energy and fire risk in households. While the thesis findings highlighted that energy usage may change on a seasonal basis, i.e. increased usage of paraffin during the winter, future research could examine the relationship between the seasonality of energy usage and dwelling fire occurrences in the study site. When discussing paraffin usage and risks with residents, a common theme that arose were the negative impacts its emissions would have upon household members. During research of literature, there appeared to be greater concern of non-electric energy sources such as paraffin, firewood and coal, contributing to indoor air pollution and being a hazard to household health rather than a potential cause of a dwelling fire. Consequently, the scope for future research to be expanded to include investigating the household energy usage, negative heath implications associated with said energy usage as well as how households may mitigate such energy-related health risks.

8 REFERENCES

8.1 LITERATURE AND SECONDARY SOURCES

Albertyn R, Rode H, Millar AJW & Peck MD 2012. The domestication of fire: The relationship between biomass fuel, fossil fuel and burns. *Burns* 38 (6): 790-795.

Babbie E R 2010. *The Practice of Social Research*. Belmont: Wadsworth Cengage

Balmer M 2007. Energy poverty and cooking energy requirements: the forgotten issue in South African energy policy. *Journal of Energy in Southern Africa* 18(3): 4-9.

Barnes B, Mathee A, Thomas E & Bruce N 2009. Household energy, indoor air pollution and child respiratory health in South Africa. Journal of Energy in Southern Africa, 20(1):4-13.

Bekker B, Eberhard A, Gaunt T, & Marquard A 2008. South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations. *Energy Policy* 36 (8): 3125-3137.

Bithas K, & Kalimeris P 2016. A Brief History of Energy Use in Human Societies. In Revisiting the Energy-Development Link. *Springer International Publishing*: 5-10

Brandt K 2017. Imizamo yethu residents pick up pieces after fire [online]. Eyewitness News. 14 March 2017. Available at: http://ewn.co.za/2017/03/13/imizamo-yethu-residents-pick-up-pieces-after-fire (Accessed 16 March 2017)

City of Cape Town (CoCT) 2007. State of Energy Report for the City of Cape Town 2007.

CoCT 2015. State of Energy Report 2015 for the City of Cape Town

Davis M 1998. Rural household energy consumption: The effects of access to electricity evidence from South Africa. *Energy Policy* 26: 207-217

Davis R 2014. Analysis: Lwandle blame-game will not fix underlying housing issues. Daily Maverick [Online] 15 July 2014. Available from: https://www.dailymaverick.co.za/article/2014-07-15-analysis-lwandle-blame-game-will-not-fix-underlying-housing-issues/#.Wbe0TLIjGUk [Accessed 4 March 2017]

de Villiers J 2017. Imizamo Yethu fire one of Cape Town's worst – deputy mayor [online] News24. 14 March 2017. Available at: http://www.news24.com/SouthAfrica/News/imizamo-yethu-fire-one-of-cape-towns-worst-deputy-mayor-20170313 [Accessed 6 March 2017]

Disaster Mitigation for Sustainable Livelihoods Programme 2010. *Community Risk Assessment Report: Samora Machel. University of Cape Tow*n: Department of Environmental & Geographical Science

DiMP 2011. *Community Risk Assessment: Report OR Thambo informal area, Mbekweni, Paarl, September 2011*. University of Cape Town: Department of Environmental & Geographical Science

DiMP 2012. Community Risk Assessment Report Mandela City. RADAR, University of Stellenbosch.

Durand-Lasserve A and Royston L 2002. Holding their ground: Secure land tenure for the urban poor in developing countries. London: Earthscan.

Eskom 2017. Incline Block Tariffs (IBT) [online]. Available at: http://www.prepayment.eskom.co.za/IBT.asp [Accessed 22 February 2017]

Eskom 2017. Tariff History: Historical average price increase [online] *Eskom*. Available from: http://www.eskom.co.za/CustomerCare/TariffsAndCharges/Pages/Tariff_History.aspx [Accessed 25 June 2017]

Fire Rescue 1 2016. 5 common causes of electrical fires [online]. 17 October 2016. Available from: https://www.firerescue1.com/fire-products/fire-safety-for-children/articles/1206100-5-common-causes-of-electrical-fires/ Available from: [Accessed 25 June 2017]

Fisher S 2016. Over 150 Homeless After Strand Shack Fire [Online]. *Eyewitness News* 23 November 2016. Available from: [Accessed 25 June 2017]

Ford S 2017. Illegal electricity connections kill 63 [online]. *Dispatch Live* 19 June 2017. Available from:http://www.dispatchlive.co.za/news/2017/06/19/illegal-electricity-connections-kill-63/ [Accessed 25 June 2017]

Fouche B 2016. Tough questions for Eskom after electrocution of nine-year-old [online]. *Groundup* 1 April 2016. Available from: http://www.groundup.org.za/article/tough-questions-eskom-after-electrocution-nine-year-old/ [Accessed 25 June 2017]

Franks L and Prasad G 2014. Informal electricity re-selling: Entrepreneurship or exploitation? Energy Research Centre, University of Cape Town, Cape Town, South Africa.

Gaunt T, Salida M, Macfarlane M, Maboda S, Reddy Y & Borchers M 2012. *Informal Electrification in South Africa: Experience, Opportunities and Challenges*. Cape Town: SEA.

Greeff AP & Lawrence J 2012. Indications of resilience factors in families who have lost a home in a shack fire. *Journal of Community & Applied Social Psychology 22*(3): 210-224.

Harte EW, Childs IRW & Hastings PA 2009. Imizamo Yethu: A case study of community resilience to fire hazard in an informal settlement Cape Town, South Africa. *Geographical Research* 47: 142–154.

Housing Development Agency (HDA) 2013. Informal Settlements in the Western Cape (2013), Research Report.

Holloway A, & Roomaney R. 2008. Weathering the Storm: Participatory risk assessment for informal settlements. Disaster Mitigation for Sustainable Livelihoods Programme (DiMP), University of Cape Town.

Household Energy Safety Association South Africa (HESASA) 2013a. Fact Sheet 1: Household energy sources

HESASA 2013b. Fact Sheet 2: Household energy-related incidents.

Hosier RH & Kipondya W 1993. Urban household energy use in Tanzania: Prices, substitutes and poverty. *Energy Policy* 21: 454-473.

Huchzermeyer, M., 2006. Informal settlements: A perpetual challenge? Cape Town: UCT Press.

ICSU & ISSC 2015. *Review of the Sustainable Development Goals: The Science Perspective*. Paris: International Council for Science (ICSU).

International Energy Agency (IEA) 2014. Africa Energy Outlook: A Focus on Energy Prospects in Sub-Saharan Africa. Paris: IEA

International Federation of Red Cross and Red Crescent Societies (IFRC) 2010. 'Chapter 2: Urban disaster trends', in World disasters report 2010 – Focus on urban risk

IOL news 2014. Shocking facts on powerless poor [online]. 27 October 2014. Available from: http://www.iol.co.za/pretoria-news/opinion/shocking-facts-on-powerless-poor-1771247 [Accessed 25 June 2017]

Ismail Z 2015. An Empirical Estimation of Energy Poverty in Poor South African Households. *Journal of Economics and Sustainable Development* 6 (13).

Keller A 2012. Conceptualising a sustainable energy solution for in situ informal settlement upgrading. Masters research thesis. Stellenbosch: Stellenbosch University, Department of Master of Economic and Management Sciences.

Kimemia DK & van Niekerk A 2017. Energy poverty, shack fires and childhood burns. *South African Medical Journal* 107 (4): 289-291.

Knight R 2004. A decade of democracy: housing, services and land in South Africa [online]. Paper delivered to Shared Interest South African delegation, Cape Town.

Knowler W 2017. Cooking with gas at their peril, as Bosch recalls gas ovens [online]. TimesLive 1 June 2017. Available from: https://www.timeslive.co.za/news/consumer-live/2017-06-01-cooking-with-gas-at-their-peril-as-bosch-recalls-gas-ovens/ [Accessed 25 June 2017]

Kovacic Z, Smit S, Musango JK, Brent AC and Giampietro M 2016. Probing uncertainty levels of electrification in informal urban settlements: A case from South Africa. *Habitat International* 56: 212-221.

Lam NL, Smith KR, Gauthier A & Bates MN 2012. Kerosene: a review of household uses and their hazards in low-and middle-income countries. *Journal of Toxicology and Environmental Health* 15(6): 396-432.

Lemaire X 2015. Informal settlements: to electrify or not? [online]. Urbanafrica.net 4 March 2015. Available from: https://www.urbanafrica.net/urban-voices/informal-settlements-electrify/ [Accessed 25 June 2017]

Lloyd P 2014a. Challenges in household energisation and the poor. *Journal of Energy in Southern Africa* 25 (2): 2-8.

Lloyd P 2014b. The energy profile of a low-income urban community. *Journal of Energy in Southern Africa* 25 (3): 1-6.

Lloyd P, Cowan B & Mohlakoana N 2004. Improving access to electricity and stimulation of economic growth and social upliftment. Energy Research Centre, University of Cape Town.

Lloyd, P 2012. Twenty years of knowledge about how the poor cook Proceedings of the Domestic Use of Energy, Cape Peninsula University of Technology.

Louw K, Conradie B, Howells M and Dekenah M 2008. Determinants of electricity demand for newly electrified low-income African households. *Energy policy* 6(8): 2812-2818.

Mawu T 2015. Lwandle residents call for RDP houses [online]. *SABC news* 17 August. Available from: http://www.sabc.co.za/news/a/c3adab804981843eac20ad09a9e64dcf/Lwandle-residents-call-for-RDP-houses [Accessed 15 February 2017]

Mehlwana AM 1997. The anthropology of fuels: situational analysis and energy use in urban low-income townships of South Africa. *Energy for sustainable development 3*(5): 5-15.

Mehlwana, M and Qase, N. 1999. The contours of domesticity, energy consumption and poverty: The social determinants of energy use in low-income urban households. Pretoria: Department of Minerals and Energy.

Mohlakoana N and Annecke W 2008. Finally breaking the barriers: South African case study on LPG use by low-income urban households. Pretoria: Human Science Research Council

Moolman S 2015. Infographic: Eskom tariff increases vs inflation since 1988 (with projections to 2017) [online]. *Power Optimal* 20 March 2015. Available from: http://www.poweroptimal.com/infographic-eskom-tariff-increases-vs-inflation-since-1988-projections-2017/ [Accessed 25 June 2017]

Muijs D 2010. Doing Quantitative Research in Education with SPSS. London: SAGE Publications.

Mvondo JM 2010. Impact of Access to Free Basic Electricity on Households' Poverty in Buffalo City Municipality in the Eastern Cape. Doctoral dissertation, University of Fort Hare.

Ndenze B 2004. Nomzamo fire victims to get new formal homes [online]. *IOL news* 21 January . available from: http://www.iol.co.za/news/south-africa/nomzamo-fire-victims-to-get-new-formal-homes-121879 [Accessed 15 February 2017]

Panday S & Mafu S 2007. Limited choices: An exploratory study on paraffin use in KwaZulu-Natal. Human Sciences Research Council

Paulsen R 2010. Paraffin stoves: Counting the cost of convenience. Paper delivered at Domestic Use of Energy proceedings, Cape Town.

Peck MD, Kruger GE, Merwe A, Godakumbura W & Ahuja RB 2002. Burns and Fires from Flammable Non-Electric Domestic Appliances. Part I. The Scope of the Problem. *Burns* 34(3): 303-11.

Pharoah R 2012. Fire risk in informal settlements in Cape Town, South Africa. In Pelling M & Wisner B (eds) *Disaster risk reduction: cases from urban* Africa. London: Earthscan.

Pharoah R, Fortune G, Chasi V & Holloway A 2013. The Environment & Risk Reduction: Focus on Urban Risk - Draft Input Paper Prepared for the IUDF Panel of Experts. Disaster Mitigation for Sustainable Livelihoods (DiMP)

Practical Action (2012) Poor people's energy outlook 2012: Energy for earning a living. Rugby: Practical Action Publishing.

Prasad G and Visagie E 2006. Impact of energy reforms on the poor in Southern Africa. *Energy Research Centre*. University of Cape Town.

Pule A 2014. Illegal electricity connections endanger lives [online] *Vuk'uzenzele*. November 2014. Available from: http://www.vukuzenzele.gov.za/illegal-electricity-connections-endanger-lives [Accessed 15 February 2017]

Research Alliance for Disasters and risk reduction (RADAR) 2014. *Community Risk Assessment Report: Chester Williams Settlement.* RADAR, University of Stellenbosch.

Rehfuess E &World Health Organization 2006. *Fuel for life: household energy and health*. Geneva: WHO Press

Rogers G & Mphande H 2017. Paraffin price hike blow for poor[online]. Herald 10 May 2017. available from: http://www.heraldlive.co.za/news/2017/05/10/paraffin-price-hike-blow-poor/ [accessed 25 June 2017]

Rosenberg, M 2013. Community Based Fire Risk Reduction: Case Study of Imizamo Yethu, Hout Bay. Unpublished MPhil Thesis, University of Cape Town

Ruiters G 2008. Free basic electricity in South Africa: A strategy for helping or containing the poor? In McDonald D (ed) *Electric Capitalism: Recolonising Africa on the power grid* 248-263. Cape Town: HSRC Press.

Schlag N & Zuzarte F 2008. Market Barriers to clean cooking fuels in Sub-Saharan Africa: A review of literature. Stockholm environment institute

Schwebel DC, Swart D, Hui SKA, Simpson J & Hobe P 2009. Paraffin-related injury in low-income South African communities: knowledge, practice and perceived risk. *Bulletin of the World Health Organization* 87 (9): 700-706.

Simmonds G and Mammon N 1996. *Energy services in low-income urban South Africa: A quantitative assessment.* Energy and Development Research Centre, University of Cape Town.

Smith HM 2005. The Relationship between Settlement Density and Informal Settlement Fires: Case Study of Imizamo Yethu, Hout Bay and Joe Slovo, Cape Town Metropolis. In Van Oosterom P, Zlatanova S, Fendel Elfriede M (eds), *Geo-information for Disaster Management*, 1333-1355. Berlin: Springer.

South Africa (Republic of) (RSA) 1998. White Paper on the Energy Policy of the Republic of South Africa. Department of Minerals and Energy (DME).

RSA 2012a. Census 2011 Statistical release – P0301.4. Pretoria: Statistics South Africa

RSA 2012b. Survey of energy-related behaviour and perceptions in South Africa: the residential sector. Pretoria: Department of Energy (DoE) 2012.

RSA 2014. General household survey 2013. Pretoria: Statistics South Africa,

Spalding-Fecher R 2005. Health benefits of electrification in developing countries: a quantitative assessment in South Africa. *Energy for Sustainable Development* 9(1): 53-62.

Sustainable Energy Africa (SEA) 2014. *Tackling Urban Energy Poverty in South Africa*. Cape Town: SEA.

SEA 2015. *Household Energy Use in Selected Areas in and around Cape Town*. Cape Town: SEA

Swart D & Bredenkamp B 2012. The challenge of addressing household energy poverty. In Strategies to Overcome Poverty and Inequality Conference. Paper delivered at Towards Carnegie III, University of Cape Town, Cape Town.

Tredoux MMJ 2009. Informal housing in Cape Town: delivery, formalization and stakeholder viewpoints. Doctoral dissertation. Stellenbosch: University of Stellenbosch, Department of Sociology and Social Anthropology.

Truran G 2009. Household energy poverty and paraffin consumption in South Africa. *Boiling Point* 56: 2-6.

Tshangana A 2013. *Local Government Position on Municipal Responses to Backyarders and Backyard*, Draft Policy Proposal. The South African Local Government Association (SALGA). Available from: http://www.nasho.org.za/wp-content/uploads/2013/09/SALGA-draft-policy-proposal_-BACKYARDERS-for-NWG-report.pdf [accessed 31 January 2018]

Uhunamure SE, Nthaduleni SN, and Agnes M 2016. Emissions and deforestation associated with household fuel wood use-a case of the Thulamela local municipality, South Africa. *Africa Insight* 45 (4): 109-128.

UN-Habitat (United Nations Human Settlements Programme) 2015. *Habitat III Issue Papers 22: Informal Settlements New York, 31 May 2015*. Geneva: United Nations Press.

United Nations 2002: Johannesburg Declaration on Sustainable Development. Geneva: United Nations Press.

United States Fire Administration (USFA) 2017. Residential Building Fires (2013-2015). *Topical Fire Report Series* 18 (1).

van der Kroon, Brouwer,R. & van Beukering P 2011. *The energy ladder: Theoretical myth or emperical truth?* [Online] Amsterdam: VU University, IVM Institute for Environmental Studies Available from: https://energypedia.info/images/f/f0/Van_der_Kroon_-_The_energy_ladder.pdf [accessed 22 June 2017]

Vermaak C, Kohler M and Rhodes DB 2009. Developing energy-based poverty indicators for South Africa. *Journal of Interdisciplinary Economics* 21 (2): 163-195.

Vermaak, C., 2014. Developing an energy-based poverty line for South Africa. Journal of Economic and Financial Sciences, 7(1), pp.127-144.

Wekesa BW, Steyn GS & Otieno FF 2011. A review of physical and socio-economic characteristics and intervention approaches of informal settlements. *Habitat international* 35(2): 238-245.

Western Cape Government 2015. Cape Strategic Framework for Fire and Burn Injury Prevention

Western Cape Government 2016a. Preventing fires in the Western Cape.

Western Cape Government 2016b. Smoke Alarm Project. Available at: https://www.westerncape.gov.za/general-publication/smoke-alarm-project [15 February 2018]

Western Cape Government 2017. Fires incidents in Cape Town. CAD System, Fire and Rescue Service. Available at: https://data.code4sa.org/dataset/Fires-incidents-in-Cape-Town/kqkd-fa8f/data [Accessed 6 February 2017].

Winkler H, Simões AF, La Rovere EL, Alam M, Rahman A & Mwakasonda S 2011. Access and affordability of electricity in developing countries. *World Development* 39 (6): 1037-1050.

Witz L 2011. Revisualising township tourism in the Western Cape: the Migrant Labour Museum and the re-construction of Lwandle. *Journal of Contemporary African Studies* 29(4): 371-388.

Wolpe P & Reddy Y 2010. Alleviating urban energy poverty the informal sector: The role for local government. Cape Town: SEA.

Zweig PJ 2015. Everyday hazards and vulnerabilities amongst backyard dwellers: A case study of Vredendal North, Matzikama Municipality, South Africa. *Jàmbá: Journal of Disaster Risk Studies* 7 (1): 1-8

8.2 PERSONAL COMMUNICATIONS

Jongidumo M 2017. Ward Councillor for Lwandle. Nomzamo. Interviews on 7 April and 11 May 2017 about households' livelihoods, energy use, fire history, service delivery issues and settlement politics.

Manuel A 2017. Divisional Commander, Fire & Rescue Service, Strand Fire Station. Strand. Interview on 20 April about dwelling fire incidences and fire risk within Lwandle, Nomzamo and Asanda

Mfecane S 2017. Ward Councillor for Nomzamo. Nomzamo. Interviews on 7 April and 14 May 2017 about households' livelihoods, energy use, fire history, service delivery issues and settlement politics.

Soko M 2017. Museum manager, Lwandle Migrant Labour Museum. Lwandle. Interviews on 24 March 2017 and between 6-7 April 2017 about Study site history, households and livelihoods, energy use and fire history.

Traut J 2017 GIS Manager for Electricity Generation & Distribution of the City of Cape Town. Cape Town. Interview on 22 February 2017 about distribution of electricity among low income residential areas and assistance in identifying potential study sites.

Van der Westhuizen J 2017. Disaster Manager Helderberg district, Strand Fire Station. Strand Interview on 20 April about dwelling fire incidences risks presented by different energy sources within Lwandle, Nomzamo and Asanda.

9 APPENCICES

APPENDIX A: CONSENT TO PARTICIPATE IN RESEARCH

Dear Participant,

You are asked to participate in a research study conducted by Alberto Paolo Francioli, an MPhil student from Stellenbosch University. The data gathered from these surveys will contribute to his research paper. You are selected as a possible participant in this study because you are believed to have knowledge and experience concerning energy usage and associated risks within Lwandle and Nomzamo that will provide valuable insight into this matter

1. PURPOSE OF THIS RESEARCH

This research aims to investigate the risks associated with energy usage among low-income households. This will include analysing incidents of urban fire across selected low-income residential areas, and examining whether physical access to formal electrical connection within low-income residential areas has influenced fire incidences. The research will also analyse the significance of energy poverty, exploring issues of access from both a physical and affordability perspective, as a driver of risk.

2. PROCEDURES

If you volunteer to participate in this study, we would ask you to partake in a semi structured interview session whose questions revolve around the following themes;

- Discussing present household energy usage
- Discussing risks/dangers that associated with the household's type of energy usage
- Discussing influence of energy poverty on household energy usage and risk
- Discussing measures that households employ to reduce their risks related to energy use

These interviews should take between 20-25 minutes; however they can go longer if necessary depending on the enthusiasm of the participant.

3. POTENTIAL BENEFITS OF THIS RESEARCH TO SUBJECTS AND SOCIETY

Potential benefits of this research could see study published in academic journals. Findings and observations from this report could be utilized by Disaster Risk Management, Municipal Departments and Urban Planners to improve upon their own knowledge and understanding of the issue, thereby creating appropriate responses to assist in addressing energy related issues such as energy poverty as well as to reduce energy related risks.

4. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with the participant will remain confidential and will be disclosed only with your permission or as required by law. All participants shall remain anonymous (as no personal or identity information is required) throughout the research, data collection, consolidation and presentation. No participant or their personal knowledge and views will be identified in the paper or in its publication. All information will be kept and only observed between myself and my academic supervisor (if the need for their observation of the data is required).

5. POTENTIAL RISKS AND DISCOMFORTS

There should be no discomfort created by this interview process, however the researcher does foresee that some participants may become uncomfortable or unwilling to discuss matter concerning their experience with particular energy related hazardous events. The Researcher will understand that if the participant does not wish to discuss that topic and will move on to other questions and themes, or whether they wish to no longer partake in this interview altogether and depart.

6. PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so. This may be because the participant does not meet the geographical criteria of residing within the formal emergency planning zone.

7. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact

MPHIL STUDENT RESEARCHER: Alberto Paolo Francioli - 0842081870 / albertofrancioli@sun.ac.za

MPHIL STUDENT SUPERVISOR : Robyn Pharoah –robynpharoah@sun.ac.za

8. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact **Ms Maléne Fouché** [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development.

APPENDIX B: HOUSEHOLD SURVEY: QUESTIONNAIRE SAMPLE

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

INVESTIGATING RISK ASSOCIATED WITH ENERGY USAGE AMONG HOUSEHOLDS IN LWANDLE AND NOMZAMO

RESEARCH FOR MPHIL STUDENT THESIS

A1	Settlement Name	
A2	Street Name[1]	
A3	Date of Visit	
A4	Survey no.	
A5	Name of Survey officer	
A5	Date of first quality control	
A6	Questionnaire finalised	
A7	Questionnaire coded	

[1] In the event you are distributing questionnaire to a household with no street name (i.e. informal households), please provide the name of the area the household is located in

1. HOUSEHOLD INFORMATION

	Question	Code	Answer
Q1.1	What is the dwelling type that this household resides in?	1= Formal dwelling 2= Informal dwelling 3= Backyard dwelling 4= Hostel	
Q1.2	How long have you been living in Lwandle/Nomzamo	Fill in numbers that correspond o years and or months	Years:__________ Months:____________

Q1.2	First name (please name the household head first)	Q1.3	Age	Q1.4	Gender 1= Male 2= Female	Q1.5	Occupation 1= fulltime employed 2= part-time employed 3= seasonally employed 4= unemployed 5= retired 6= student
1.2.1		1.3.1		1.4.1		1.5.1	
1.2.2		1.3.2		1.4.2		1.5.2	
1.2.3		1.3.3		1.4.3		1.5.3	
1.2.4		1.3.4		1.4.4		1.5.4	
1.2.5		1.3.5		1.4.5		1.5.5	
1.2.6		1.3.6		1.4.6		1.5.6	
1.2.7		1.3.7		1.4.7		1.5.7	
1.2.8		1.3.8		1.4.8		1.5.8	
1.2.9		1.3.9		1.4.9		1.5.9	
1.2.10		1.3.10		1.4.10		1.5.10	

	Question	Code	Answer
1.6	Would you describe your household's income as....	1= regular 2= irregular 3= seasonal 4= no income 5= rely on social grants -1= Don't know -2= refuses to answer	
1.7	Which category would your household's monthly income fall under?	1= No income 2= R1 - R1500 3= R1501 – R3500 4= R3501 – R5000 5= R 5001 – R10000 6= R10 000 + -1= Don't know -2= refuses to answer	

1.8	Does your dwelling have access to electricity? if no, proceed to question 1.12	1= Yes 2= No → Go to question 1.12	
1.9	If so, how do you access it	1= Directly from meter box/from Eskom 2= Connected to a neighbour 3= Connected to a landlord 4= Informally connected to a Eskom box/power pole 5= Sustainable energy (i.e. solar panel) -1= Don't know -2= refuses to answer Other (specify) ________________________	
1.10	When did you first get access to electricity?	Year: ____________________	
1.11	Have you increased your usage of electricity over time?	1= Yes 2= No -1= Don't know	
1.12	Do you share/sell electricity to another dwelling (for example a Backyard dwelling)	1= Yes 2= No → Go to question 1.14	
1.13	If yes, how many dwellings are connected to your electricity supply?	No of dwellings: ____ ____	
1.14	Do you use a mixture of different energy sources to meet your needs? e.g. using electricity and paraffin	1= Yes 2= No	
1.15	Which of these Energy based appliances do you have and use in your dwelling?		
1.15.a	Electric stove	1= Yes I own one and use it all the time 2= Yes I own one and use it most of the time 3= Yes I own one, but I use only sometimes 4= Yes I own one, but I use it rarely 5= No, I do not own or use one of these -1= Don't know -2= refuses to answer	
1.15.b	Paraffin stove		
1.15.c	Gas Stove		
1.15.d	Stove kettle		
1.15.e	Electric Kettle		
1.15.f	TV		
1.15.g	Computer/laptop		
1.15.h	Cell phone charger		
1.15.i	Iron		
1.15.j	Fridge		
1.15.k	Microwave		
1.15.l	Washing machine		
1.15.m	Sound system/Radio		
1.15.n	Toaster		
1.15.o	Electric Heater		
1.15.p	Gas Heater		
1.15.q	Paraffin Heater		
1.15.r	Mbawula		
1.15.X	Other: ____ ____		
	Other: ____ ____		
	Other: ____ ____		

2. HOUSEHOLD ENERGY USAGE

No.	Questions	Code	Electricity	Paraffin	Candles	Gas	Wood/ biofuel	Coal	Solar water geyser	Other (please write in the block when appropriate)
2.1.	How frequently do you use … for lighting in your dwelling?	1= all the time 2= most of the time 3= sometimes 4= rarely 5= never 6= only when I have no choice -1= I do not know	Electricity Q2.1.1	Paraffin Q2.1.2	Candles Q2.1.3	Gas Q2.1.4	Biofuel (wood) Q2.1.5	Coal Q2.1.6	Solar water geyser Q2.1.7	Other Q2.1.8
2.2	How frequently do you use … for cooking in your dwelling?	1= all the time 2= most of the time 3= sometimes 4= rarely 5= never 6= only when I have no choice -1= I do not know	Electricity Q2.2.1	Paraffin Q2.2.2	Candles Q2.2.3	Gas Q2.2.4	Biofuel (wood) Q2.2.5	Coal Q2.2.6	Solar water geyser Q2.2.7	Other Q2.2.8
2.3	How frequently do you use … for heating your dwelling?	1= all the time 2= most of the time 3= sometimes 4= rarely 5= never 6= only when it is very cold 7= only during winter months -1= I do not know	Electricity Q2.3.1	Paraffin Q2.3.2	Candles Q2.3.3	Gas Q2.3.4	Biofuel (wood) Q2.3.5	Coal Q2.3.6	Solar water geyser Q2.3.7	Other Q2.3.8
2.4	How frequently do you use … for boiling water in your dwelling?	1= all the time 2= most of the time 3= every now and again 4= rarely 5= never 6= only when I have no choice -1= I do not know	Electricity Q2.4.1	Paraffin Q2.4.2	Candles Q2.4.3	Gas Q2.4.4	Biofuel (wood) Q2.4.5	Coal Q2.4.6	Solar water geyser Q2.4.7	Other Q2.4.8
2.5	How frequently do you use … for powering electronic appliances and devices? (cellphones, TV, sound systems etc)	1= all the time 2= most of the time 3= every now and again 4= rarely 5= never 6= only when I have no choice -1= I do not know	Electricity Q2.5.1	Paraffin Q2.5.2	Candles Q2.5.3	Gas Q2.5.4	Biofuel (wood) Q2.5.5	Coal Q2.5.6	Solar water geyser Q2.5.7	Other Q2.5.8

No.	Questions	Code	Electricity	Paraffin	Candles	Gas	Biofuel (wood)	Coal	Solar water geyser	Other (please write in the block when appropriate)
2.6	How affordable is it for your household to purchase ...?	1= very affordable 2= reasonably affordable 3= so-so 4= expensive 5= very expensive -1= I do not know	Electricity Q2.6.1	Paraffin Q2.6.2	Candles Q2.6.3	Gas Q2.6.4	Biofuel (wood) Q2.6.5	Coal Q2.6.6	Solar water geyser Q2.6.7	Other Q2.6.8
2.7	How much do you estimate you spend on ... per week/month on average?	write an amount in Rands	R	R	R	R	R	R	R	Other
2.8	How easy is it to buy/acquire... ?	1= Always easy 2= usually easy 3= so-so 4= Sometimes difficult 5= Always difficult -1= I do not know	Electricity Q2.8.1	Paraffin Q2.8.2	Candles Q2.8.3	Gas Q2.8.4	Biofuel (wood) Q2.8.5	Coal Q2.8.6	Solar water geyser Q2.8.7	Other Q2.8.8
2.9	How efficient is ... in meeting your household energy needs?	1= very efficient 2= efficient 3= so-so 4= inefficient 5= very inefficient -1= I do not know	Electricity Q2.9.1	Paraffin Q2.9.2	Candles Q2.9.3	Gas Q298.4	Biofuel (wood) Q2.9.5	Coal Q2.9.6	Solar water geyser Q2.9.7	Other Q2.9.8
2.10	How happy are you using ... at your dwelling?	1= very happy 2= happy 3= so-so 4= unhappy 5= very unhappy	Electricity Q2.10.1	Paraffin Q2.10.2	Candles Q2.10.3	Gas Q2.10.4	Biofuel (wood) Q2.10.5	Coal Q2.10.6	Solar water geyser Q2.10.7	Other Q2.10.8
2.11	Is ... your preferred source of energy for your dwelling?	1= yes 2= no	Electricity Q2.11.1	Paraffin Q2.11.2	Candles Q2.11.3	Gas Q2.11.4	Biofuel (wood) Q2.11.5	Coal Q2.11.6	Solar water Q2.11.7	Other Q2.11.8
2.12	How safe do you feel using ... at your dwelling?	1= very safe 2= safe 3= so-so 4= unsafe 5= very unsafe	Electricity Q2.12.1	Paraffin Q2.12.2	Candles Q2.12.3	Gas Q2.12.4	Biofuel (wood) Q2.12.5	Coal Q2.12.6	Solar water geyser Q2.12.7	Other Q2.12.8
2.13	Indicate how dangerous you believe each of these energy sources are? (answer for all sources, not just the ones you use)	1= very safe 2= safe 3= so-so 4= dangerous 5= very dangerous	Electricity Q2.13.1	Paraffin Q2.13.2	Candles Q2.13.3	Gas Q2.13.4	Biofuel (wood) Q2.13.5	Coal Q2.13.6	Solar water geyser Q2.13.7	Other Q2.13.8

3. ENERGY RELATED FIRE RISKS

No.	Question	Code	Answer
3.1	how high do you think the risk of fire is in your dwelling?	1= High 2= Medium 3= Low -1= Don't know	
3.2	how high do you think the risk of fire is in your community/neighbourhood	1= High 2= Medium 3= Low -1= Don't know	
3.3	What do you think the 4 MOST COMMON causes of fires in your community/neighbourhood are? (SELECT NO MORE THAN 4 OPTIONS)	1= candles knocked over or left unattended 2= paraffin appliance explosion 3= gas appliance leak/explosion 4= using an open fire/ mbawula 5= child left alone with something flammable 6= cooking accident 7= someone fell asleep with something burning 8= alcohol related behaviour – then falling asleep while cooking 9= faulty electric wires and plugs within dwelling 10= faulty electric wires connecting houses 11= electricity meter box overloaded 12= faulty electric appliance 13= leaving an electric appliance on 14= deliberately started fires (arson) Other (specify) ______________________________ ______________________________	
3.4	Do you believe that the energy sources you use make your dwelling more vulnerable to fire	1= Yes 2= No -1= Don't know	
3.5	Do you think increased access to and usage of electricity may reduce fire risk	1= Yes 2= No -1= Don't know	
3.6	Have you experienced a fire in your dwelling? If no, go to Q 3.10	1= Yes 2= No → go to 3.15 -1= Don't know	
3.7	How many fires have affected your household?	Number of fires: ______________	
3.8	How many of these fires were started by an energy source?	Number of fires: ______________	

	3.9when did this fire occur?	3.10 What was the energy related cause of the fire	3.11 What were the impacts of the fire	3.12 Were there any injuries	3.14 What were the consequences of the fire
	Give approximate time of day, month and year	1= Candles knocked over or left unattended 2= Paraffin appliance explosion 3= Gas appliance leak/explosion 4= Using an open fire/ mbawula 5= Child left alone with something flammable 6= Cooking accident 7= Someone fell asleep with something burning 8= Alcohol related behaviour 9= Faulty electric wires and plugs within dwelling 10= faulty electric wires connecting houses 11= electricity meter box overloaded 12= Faulty electric appliance 13= Leaving an electric appliance on 14= Deliberately started fires (arson) Other (specify in box)	1= No damage to house or belongings 2= some damage to dwelling and or belongings 3= major damage to dwelling and belongings 4= Dwelling and belongings destroyed Other (specify in box)	1= No injuries 2= slight injuries 3= major injuries 4= loss of life Other (specify in box)	1= household did not have to leave the dwelling 2= household displaced temporarily until repairs finished 3= household displaced and forced to move into new dwelling Other (specify in box)
Fire 1					
Fire 2					
Fire 3					
Fire 4					

3.15	Briefly describe what measures you take to reduce your household's risk to energy related fires

4. OTHER DANGERS AND BENEFITS ASSOCIATED WITH ENERGY

No.	Questions	
5.1	Briefly describe or list at least 3 positive and 3 negative things about using ELECTRICITY in dwellings in your community	
	Positive .	Negative
5.2	Briefly describe or list at least 3 positive and 3 negative about using PARAFFIN in dwellings in your community	
	Positive	Negative
5.3	Briefly describe or at least 3 positive and 3 negative things about using GAS in dwellings in your community	
	Positive .	Negative

5.4	Briefly describe or at least 3 positive and 3 negative things about using CANDLES in dwellings in your community	
	Positive	Negative
5.5	Briefly describe or list some of the good and bad things about using BIOFUEL SOURCES SUCH AS WOOD OR COAL in dwellings in your community	
	Positive .	Negative
5.6	Briefly describe or list some of the good and bad things about ANY OTHER ENERGY SOURCES that are used by dwellings in your community that have not been mentioned before	
	Positive .	Negative

APPENDIX C: SEMI-STRUCTURED IN-DEPTH INTERVIEW WITH SELECTED PARTICIPANTS

Interview questions with residents and community leaders of low-income households areas:

1. **Identify household characteristics**
   a) Identify type of dwelling,
   b) No. of household members and general demographic information
   c) Identify whether dwelling has access to formal or informal electrical connections
   d) Make notes and observations on energy sources and appliances in the household

2. **Discuss present and historical household energy usage**
   a) What types of energy household uses to meet basic needs and why? - utilise Energy mix matrix table (see below)
   b) Have energy household changed overtime and why?– reapply Energy mix matrix table if necessary
   c) What positive and negative attributes are associated with these energy sources

3. **Discuss influence of energy poverty on household energy usage and fire risk.**
   a. Assess household spending on energy
   b. ascertain what proportion of household income is spent on energy
   c. calculate whether energy impoverished
   d. Enquire about participants perceptions concerning access to energy

4. **Discuss what risks are associated with the household's type of energy usage**
   a. What risks are associated with particular energy sources used by household
   b. What incidents related to energy generated risks has the household experienced or been exposed too
   c. How safe do they feel utilising these energy sources
   d. Has household risk changed with changing energy usage?
   e. discuss whether they feel energy poverty has influenced their risk to energy related fires

5. **Discuss whether household employs any measures to reduce their fire risk.**

Interview questions with Disaster risk management personnel and emergency responders:

1. Discuss recent fire history
    a. Discuss common causes of fire in specific study sites
    b. How significant are energy sources to contributing to fire
2. Discuss influence of energy usage and fire risk in specific study sites
    a. Enquire what are the positive and negative factors of using this/these types of energy sources regarding fire risk
    b. Does energy sources influence methods of fire fighting?
    c. Enquire whether they have noticed a decline in fire frequency among areas with more formal/modern electrical areas
3. Enquire what is the best means to reduce their risk to fires caused by energy usage among households
4. Enquire what initiatives/programmes have been taken to reduce fire risk among low income residential areas
5. Enquire what are the costs of fighting urban fires in the municipality

Interview questions with City of Cape Town officials and NGOs:

1. Discuss issues regarding energy accessibility of low income households in specific study sites
2. Enquire what initiatives/programmes have been taken to reduce fire risk among low income households by local government/NGOs and other stakeholders in specific study sites
3. Enquire what initiatives/programmes have been taken to reduce energy poverty among low income Households by local government/NGOs and other stakeholders
4. Enquire what solutions they believe are necessary to reduce fire risk and or energy poverty

APPENDIX D: KEY TABLES OF GRAPHS AND CHARTS USED IN THE THESIS

Table 6 Number of households surveyed according to settlement and dwelling type

	Lwandle	Nomzamo	Asanda	Total
Formal	153	84	51	288
Informal	41	44	9	94
BYD	64	61	23	148
Total	258	189	83	530

Table 7 Household income across study site

	Refuses to answer	Do not know	No Income	R1 - R1499	R1501 - R3499	R3501 - R4999	R5001 - R9999	R10000+	total
Formal	127	25	3	40	44	34	14	0	287
Informal	18	8	2	25	30	9	2	0	94
BYD	29	13	21	33	23	20	7	2	148

Table 8 Household access to electricity across study site

Dwelling type	Refuses to answer	Directly from meter box/from Eskom	Informally Connected to a neighbour	Connected to a landlord	Informally connected to Eskom/power pole	Sustainable energy	Totals
Formal	6	239	16	8	15	1	285
Informal	6	3	17	14	50	3	93
BYD	7	17	10	95	7	0	136

Table 9 Energy sources used for lighting across study site

Energy source	Dwelling type	Always	Mostly	Occasionally	Rarely	Never	Only if I have no choice	Totals
Electricity	Formal	245	34	7	2	0	0	288
	ISD	72	17	3	0	1	0	93
	BYD	129	14	5	0	0	0	148
Paraffin	Formal	3	36	52	38	149	8	286
	ISD	0	10	20	11	47	6	94
	BYD	0	3	14	4	122	1	144
Candles	Formal	3	10	100	26	76	72	287
	ISD	0	6	38	4	28	18	94
	BYD	0	1	27	8	72	39	147

Table 10 Energy sources used for cooking across study site

Energy source	Dwelling type	Always	Mostly	Occasionally	Rarely	Never	Only if I have no choice	Totals
Electricity	Formal	184	77	16	4	6	0	287
	ISD	38	36	7	3	10	0	94
	BYD	117	25	5	0	1	0	148
Paraffin	Formal	1	16	79	21	128	41	286
	ISD	3	20	26	6	29	10	94
	BYD	0	6	31	13	82	15	147
Gas	Formal	0	10	48	24	189	14	285
	ISD	6	16	16	8	43	5	94
	BYD	0	7	7	4	124	6	148
Firewood	Formal	0	1	7	24	252	4	288
	ISD	0	5	7	1	81	0	94
	BYD	0	0	5	0	142	1	148
Coal	Formal	0	1	15	20	250	2	288
	ISD	0	3	9	0	82	0	94
	BYD	0	0	4	0	142	0	146

Table 11 Energy sources used for boiling water across study site

Energy source	Dwelling type	Always	Mostly	Occasionally	Rarely	Never	Only if I have no choice	Totals
Electricity	Formal	203	65	8	2	6	0	284
	ISD	57	22	6	0	9	0	94
	BYD	100	42	3	0	2	1	148
Paraffin	Formal	7	14	58	29	119	49	276
	ISD	2	19	27	7	31	8	94
	BYD	0	7	17	23	77	23	147
Gas	Formal	0	10	41	58	166	13	288
	ISD	5	7	19	6	51	6	94
	BYD	0	5	8	8	123	4	148
Firewood	Formal	0	9	19	52	203	5	288
	ISD	0	2	6	12	70	4	94
	BYD	0	0	4	6	138	0	148
Coal	Formal	0	2	9	52	222	2	287
	ISD	0	3	7	12	71	1	94
	BYD	0	0	3	5	140	0	148
Solar water Geyser	Formal	203	65	8	2	6	0	284
	ISD	0	10	0	0	84	0	94
	BYD	0	3	0	2	143	0	148

Table 12 Energy sources used for heating across study site

Energy source	Dwelling type	Always	Mostly	Occasionally	Rarely	Only when it is very cold	Only in winter	Never	total
Electricity	Formal	102	49	30	16	18	8	63	286
	ISD	29	11	9	3	4	2	35	93
	BYD	26	17	11	21	3	4	64	146
Paraffin	Formal	14	27	51	16	62	33	85	288
	ISD	1	12	33	2	10	19	17	94
	BYD	0	11	16	4	27	20	69	147
Gas	Formal	0	10	61	11	21	3	182	288
	ISD	0	1	24	0	4	1	64	94
	BYD	1	2	9	2	4	2	128	148
Biofuel	Formal	0	0	39	0	44	0	205	288
	ISD	0	0	23	0	2	0	69	94
	BYD	0	0	8	0	3	0	137	148
Coal	Formal	0	1	32	3	43	1	207	287
	ISD	0	0	21	0	1	0	72	94
	BYD	0	0	7	0	2	0	139	148

Table 13 Residents' perceptions of affordability of different energy sources across study site

Energy source	Dwelling type	Very affordable	Reasonably affordable	So-so	Expensive	Very expensive	totals
Electricity	Formal	59	82	43	71	28	283
	ISD	17	11	12	38	3	81
	BYD	9	68	15	43	10	145
Paraffin	Formal	54	87	36	25	9	211
	ISD	6	36	14	15	0	71
	BYD	10	27	23	6	3	69
Candles	Formal	158	34	7	8	5	212
	ISD	39	17	3	1	0	60
	BYD	53	11	3	0	0	67
Gas	Formal	13	39	18	51	21	142
	ISD	2	16	2	21	5	46
	BYD	6	9	2	4	4	25
Firewood	Formal	11	17	34	23	1	86
	ISD	1	3	18	1		23
	BYD	1	1	5	3		10
Coal	Formal	8	10	29	28	7	82
	ISD	2	3	7	9	0	21
	BYD	0	2	3	4	0	9

Table 14 Residents' perceptions of accessibility of different energy sources across study site

Energy source	Dwelling type	Very affordable	Reasonably affordable	So-so	Expensive	Very expensive	totals
Electricity	Formal	59	82	43	71	28	283
	ISD	17	11	12	38	3	81
	BYD	9	68	15	43	10	145
Paraffin	Formal	54	87	36	25	9	211
	ISD	6	36	14	15		71
	BYD	10	27	23	6	3	69
Candles	Formal	158	34	7	8	5	212
	ISD	39	17	3	1	0	60
	BYD	53	11	3		0	67
Gas	Formal	13	39	18	51	21	142
	ISD	2	16	2	21	5	46
	BYD	6	9	2	4	4	25
Firewood	Formal	11	17	34	23	1	86
	ISD	1	3	18	1	0	23
	BYD	1	1	5	3	0	10
Coal	Formal	8	10	29	28	7	82
	ISD	2	3	7	9	0	21
	BYD	0	2	3	4	0	9

Table 15 Residents' perceptions of level of danger different energy sources pose towards fire risk across study site

Energy source	Dwelling type	Very safe	Safe	So-so	dangerous	Very Dangerous	Totals
Electricity	Formal	159	70	19	32	5	285
	ISD	35	15	10	30	3	93
	BYD	78	40	8	14	5	145
Paraffin	Formal	2	41	64	76	16	199
	ISD	0	19	20	35	8	82
	BYD	2	18	20	38	11	89
Candles	Formal	159	70	19	32	5	285
	ISD	0	8	24	43	10	85
	BYD	2	13	29	68	19	131
Gas	Formal	1	17	69	67	54	208
	ISD	0	6	13	36	26	81
	BYD	0	1	11	38	65	115
Firewood	Formal	7	61	60	33	16	177
	ISD	4	25	18	14	7	68
	BYD	1	71	14	13	4	103
Coal	Formal	27	54	11	77	4	173
	ISD	7	28	3	21	8	67
	BYD	17	61	8	12	3	101